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The Intellectual Resemblance of Twins

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CONTENTS

INTRODUCTION

At least three important biological problems are connected with the phenomenon of twinning: (1) The problem of twinning as a variation in the normal method of human reproduction. (2) The problem of sex determination. (3) The problem of the relative influence of hereditary and environmental factors in human development.

In this study no attempt will be made to do original work on the strictly physical aspect of the problem. We shall be satisfied with stating fairly the generally accepted biological views, and pointing out some of the implications of these views. The purpose of the study is primarily psychological and bears chiefly on the following questions:

1. What is the effect of environment upon the amount of intellectual resemblance of twins?
2. Does the fact of twin origin and birth operate in any way to lower the intellectual level of a twin population?
3. What light do the psychological data throw upon the current biological belief that there are two distinct types of twins, fraternal and duplicate?

THE COLLECTION OF DATA

Three possible sources of data presented themselves for consideration. First, it was necessary to secure data on the intellectual behavior of each twin when he worked alone. It was immediately evident that the Stanford-Binet was the most desirable instrument for this purpose. Second, it seemed desirable to have some kind of estimate given by some one who knew the members of the twin pair intimately. For this it was decided to obtain a teacher rating on a number of traits which are commonly accepted as primarily intellectual in nature. Third, it was desirable to supplement both of the above by group tests. For this purpose two types were used, The National Intelligence Test, and a modified form of the Army Beta. The latter was used to get as far away as possible from the verbal factors represented in the other tests.

The following data were obtained:

1. Stanford-Binet tests for ..... 105 pairs
2. Teacher estimates for ..... 90 pairs
3. Army Beta tests for ..... 76 pairs
4. National Intelligence tests for..... 143 pairs

In the collection of the data, every known precaution was taken to insure the validity of the results. Of these precautions the following may be mentioned:

1. All tests were given by trained examiners. Besides having studied the books and manuals on testing, each person had given a considerable number of tests under the personal supervision of a psychologist. It is believed, therefore, that the procedure was as nearly uniform as it was possible to make it.

2. In almost all cases the Stanford-Binet test was given to the two members of a twin pair by the same person, the test of the second twin following immediately upon that of the first.

3. All group tests were given to both members of a pair at the same sitting.

4. Extreme care was taken to make sure that the children were

actually twins. Strangely enough, two cases were found of children who were passing as twins, but were not twins.

5. The twin population tested was limited to those found in the eight grades of the elementary schools. This was done because of the inadequacy of some of our tests when used above or below certain age ranges. For example, the National Test was not designed to measure beyond a level represented by the brighter children in the eighth grade. The limitation of the survey to the eight grades also made it possible to avoid certain undesirable selective factors.

6. Every possible effort was made to secure data upon every twin pair in a given school population. All the schools included in this study are co-educational. This made it as easy to locate twins of unlike sex as twins of like sex. Extreme care was taken on this point. The school principal or city superintendent cooperated by calling teachers' meetings. Statements were made before the entire school. Diligent inquiry was made of the children themselves on the playgrounds. It was announced in the newspapers that a search was being made for twins. It is believed, therefore, that factors which could have produced a systematic tendency to overlook cases which were not in the same grade, or which did not resemble, were pretty completely eliminated. In a later part of the study, data will be presented on the number of twins that appear in a general population, and on the relative number of like sex and unlike sex pairs. It is interesting to note that in the populations covered by this study the actual number of twins found agrees closely with the observed frequency in the general population. The same is true as regards the relative number of like and unlike sex pairs. These facts give added weight to the statement that there was present no systematic tendency to overlook any cases.

Before presenting the tables which give the results of the various tests, it is necessary to call attention to the test procedures employed.

The procedure used in the Stanford-Binet tests and the method of recording responses conformed strictly with the directions set forth in Terman's "The Measurement of Intelligence." All items of the tables are self explanatory except in the starred cases show-

ing different chronological ages for the two members of a pair. This resulted from the tests being given at different times.

The National Intelligence Test was given and scored according to the 1920 edition of the manual.

The procedure used in giving the Army Beta test was somewhat modified. In its original form this test was given by pantomime because it was designed for use with non-English speaking men. Inasmuch as all the twins could speak and understand the English language, the following verbal form of instructions was used. Only the verbal instructions will be shown. The charts that were used were similar to the actual test figures, and the general procedure was much the same as is used with the exercises of the National Test. The content of the tests and the method of scoring were exactly the same as for the original Army Beta.

BETA TEST

ATTENTION—Pencils up. I am going to show you some drawings like examples you will have to work in this examination. I will illustrate the examples, and you are to do all the examples in each test. Always, pencils up, when I say stop.

TEST I

ATTENTION—Pencils up. Look at this drawing, marked Test I. Here are some alleys. Watch me as I try to run through them as quickly as I can without crossing any lines. I am going to go from this arrow to this one and must find and mark the path.

Now—Look at your papers. Test I. You are to trace the path through them as fast as you can, and be sure not to cross any lines, but find the way out.

Go—Stop. (2 minutes)

TEST II

ATTENTION—Look at this drawing. Here are some blocks piled up. Watch me while I count them. Then I put the 3 in the square here. Watch while I count these. Then I put the 9 in the square below.

Now—Look at this drawing. Test II. You are to count the number of blocks in each drawing as if you could see them all, and put the number in the square.

Go—Stop. (2½ minutes)

TEST III

ATTENTION—Here are some little circles and crosses. You see the first row with the circles. Some of the spaces are empty. I fill the spaces thus O, O, O, until all the rest of the spaces are filled. (E repeats with other rows.)

Now—Look at your papers. Test III. You see the crosses and the little circles. You are to fill out the blank squares at the end, as the row has been started. Do all the rows.

Go—Stop. (1¾ minutes)

TEST IV

ATTENTION—Look at these drawings. Here are some numbers with drawings below them. Below are rows of the same numbers with empty squares below them. Watch what I do. I put the right drawing with the number to which it belongs. Go all the way through each row.

Now—Look at your papers. Test IV. You are to put the right drawing in every blank square below the number which it goes with. Go through every row to the end.

Go—Stop. (2 minutes)

TEST V

ATTENTION—Look at these figures. Some of the numbers on each side are the same. Some are almost the same but not quite. Watch what I do.

Now—Look at your papers. Test V. If the two numbers are the same put a cross on the dotted line. If the two numbers are not the same do nothing.

Go—Stop. (3 minutes)

TEST VI

ATTENTION—Look at this drawing. There is something missing. What is it? (Gets response and draws in figure.) (Repeat.)

Now—Look at your papers. Test VI. In each picture draw in the part that is missing. Don't try to make it pretty. Fix them all.

Go—Stop. (3 minutes)

TEST VII

ATTENTION—Look at this drawing. I put the figures into the square like this. They fit. Watch where the lines should be drawn to show how they fit.

Now—Look at your papers. Test VII. You are to draw the lines which show how the little pieces fit into the squares.

Go—Stop. (2½ minutes)

TEST VIII

As this test was omitted in army use, it will not be used in this study.

The teacher rating was secured by means of a special blank of which the following is a copy:

In each trait or characteristic named below compare this child with the average child of the same age. Then in the square before the name of the trait, place the figure 1, 2, 3, 4, or 5. These figures are to be used with the following meanings:

1—Very Superior to the average child of this age;
2—Superior to the average child of this age;
3—Average;
4—Inferior to the average child of this age;
5—Very Inferior to the average child of this age.

( ) Memory.
( ) Imagination (Ability to think about things not present to the senses.)
( ) Reasoning (Ability to see meanings or to follow a complicated train of thought.)
( ) Judgment or common sense.

( ) Resourcefulness in overcoming difficulties or attaining ends.
( ) Originality (As shown by inventiveness or by ingenuity in finding explanations.)
( ) Curiosity (As shown by inquisitiveness or eagerness to learn.)
( ) Mechanical Ingenuity (Ability to think out mechanical contrivances. May exist without manual dexterity.)
( ) General Intelligence.
( ) Studiousness.
( ) Interest in objective things (plants, tools, etc.)
( ) Interest in books.
( ) Breadth and Variety of Interests.

The recorded grade for the teacher rating in Intellectual Traits is the mean of the various ratings. It should be borne in mind that the rating 1 is highest and 5 the lowest.

The test results were then tabulated according to the following form:

	SEX	GRADE	C.A.	BINET M.A.	BINET I.Q.	TEACHER RATING	BETA	N.I.T.
Pair 1	F	1	5-10	6-6	112	....	....	....
	F	1	5-10	6-8	114	....	....	....
Pair 2	M	2b	6-11	7-6	108	1.5	39	28
	F	2b	6-11	7-4	106	2.2	45	44

Table 1 shows the distribution of ages, the number who took the various types of tests and the total number of pairs studied.

Appendix A gives the results of the various tests. The original scores are reported so that any one who cares to do so may make further study of the data.

TABLE 1

General Summary of Data

AGE	BINET	TEACHER	BETA	N.I.T.
5	1	0	0	0
6	9	8	3	1
7	11	8	7	2
8	11	11	7	14
9	15	12	11	21
10	9	9	8	16
11	10	7	7	17
12	15	12	12	26
13	10	10	11	21
14	9	9	8	13
15	3	3	2	10
16	2	1	0	1
18	0	0	0	1
Totals	105	90	76	143

THE EFFECTS OF ENVIRONMENT

Galton made a general comparison of two groups of twins (Galton, Francis: Inquiries into Human Faculty, Everyman's Library, 1883, pages 155-172.) One group consisted of 35 pairs showing marked similarity in infancy, the similarity being sometimes so pronounced as to cause confusion of identity. The second group was composed of 20 pairs of distinctly dissimilar twins. For the second group the environment had remained substantially the same. The excess of difference in the first case, and of resemblance in the second, was thought to give a measure of the influence of environment. The persistence of similarities in the first case and of differences in the second was taken as a measure of the influence of nature. Galton quotes from many letters of parents showing how the original likeness or difference remained through childhood to adult life. He summarizes as follows:

> "We may, therefore, broadly conclude that the only circumstance, within the range of those by which persons of similar conditions of life are affected, that is capable of producing a marked effect on the character of adults, is illness or some accident that causes physical infirmity. The impression that all this leaves on the mind is one of some wonder whether nurture can do anything at all, beyond giving instruction and professional training. There is no escape from the conclusion that nature prevails enormously over nurture when the differences of nurture do not exceed what is commonly to be found among persons of the same rank of society and in the same country." (p. 172)

At least two comments are in place concerning Galton's work as briefly outlined above: (1) He secured his results by the questionnaire method—a method which investigators in the field of verbal report have shown to have many sources of error. (2) In spite of the imperfections of Galton's method, his general conclusion as to persistence of nature has been fairly widely accepted.

In 1905 Thorndike (Thorndike, E. L.: Measurement of Twins, *Archives of Philosophy, Psychology, and Scientific Methods,* Number One, September, 1905.) published a report of the measurement of resemblance of fifty pairs of twins in certain specific mental traits. The traits used and the resulting resemblances were as follows:

1. Marking A's on page of capital letters..... r = .69
2. Marking words containing *at* or *re* ..... r = .71
3. Marking misspelled words ..... r = .80
4. Solving addition problems ..... r = .75
5. Solving multiplication problems ..... r = .84
6. Writing the opposites of a set of words..... r = .90

Having found the resemblance for the twin population as a whole, Thorndike attacked the problem of the effects of environment. His argument is as follows:

"If now these resemblances are due to the fact that the two members of any twin pair are treated alike at home, have the same parental models, attend the same school and are subject in general to closely similar environmental conditions, then,

1. Twins should up to the age of leaving home grow more and more alike, and in our measurements the twins 13 and 14 years old should be much more alike than those 9 and 10 years old. Again,

2. If similarity in training is the cause of similarity in mental traits, ordinary fraternal pairs not over four or five years apart in age should show a resemblance somewhat nearly as great as twin pairs, for the home and school conditions of a pair of the former will not be much less similar than those of a pair of the latter. Again,

3. If training is the cause, twins should show greater resemblance in the case of traits much subject to training, such as ability in addition or in multiplication, than in traits less subject to training, such as quickness in marking A's on a sheet of printed capitals or in writing the opposites of words.

On the other hand,

1. The nearer the resemblance of young twins comes to equaling that of old, and

2. The greater the superiority of twin resemblance to ordinary fraternal resemblance is, and

3. The nearer twin resemblance in relatively untrained capacities comes to equaling that in capacities at which the home and the school direct their attention, the more must the resemblances found be attributed to inborn traits."

For the detailed statistics, methods, and conclusions of Thorndike's study the reader must go to the original monograph. The following quotation will suffice to show how Thorndike takes his stand alongside Galton on the general problem of nature and nurture.

"The facts then are easily, simply, and completely explained by one simple hypothesis: namely, that the natures of the germ cells—the conditions of conception—cause whatever similarities and differences exist in the original natures of men, that these conditions influence body and mind equally, and that in life the differences produced by such differences as obtain between the environments of present day New York City public school children are slight."

However, neither the work of Galton nor that of Thorndike is entirely conclusive. In the first place, Galton depended upon a verbal report method. Thorndike knew the weakness of this method and made use of a series of mental tests, but tests of a kind far inferior to those at present available. Later experimental results have considerably discredited most of the tests he used, as far as the measurement of *general intelligence* is concerned. It is to be stated, however, that Thorndike made no claims for these tests as measures of general intelligence. He plainly says he is reporting only the results of the measurement of 50 pairs of twins in these specific abilities, viz., marking A's, etc. He plainly states that he makes no claims as to what might be found for other mental functions, except as we may infer from the probably reigning likeness between abilities. In the second place, Thorndike doubts whether he has completely eliminated the possible effects of home and school influence. The Binet and other forms of intelligence tests appear to meet this requirement more satisfactorily, and are therefore used in this study.

Because of these differences in approach, it could not be fore-

seen whether the results of the present study would or would not support the conclusion of Thorndike. Both because of its nature and its careful standardization the Binet test ought to throw new light on the intellectual resemblance of twins. For similar reasons the various group tests should also be of great service, especially in making it possible to deal with a large population in a relatively short time.

Before presenting our results it is necessary to indicate the statistical procedures employed. All correlations were derived by the use of the Pearson product-moment formula. The tables will show the correlation coefficient, the probable error, and the number of cases (pairs) used in the calculations. The scores used in these calculations were as follows:

1. For the Stanford-Binet correlations, the Stanford-Binet I.Q. as shown in Appendix A.
2. For the Teacher correlations, the ratings as shown in Appendix A.
3. For the Beta correlations, the raw Beta scores as shown in Appendix A.
4. For the N.I.T. correlations, the raw N.I.T. scores, as shown in Appendix A.

Table 2 shows the coefficients of correlation based upon the Stanford-Binet I.Q. for the various groups of young pairs as compared with the old pairs.

TABLE 2

1.	All pairs,	5 to 9 years,	r = .809 ± .032	with	47	pairs
	All pairs,	10 to 16 years,	r = .757 ± .037	"	58	"
		Difference	= .042 ± .048			
2.	Like sex,	5 to 9 years,	r = .882 ± .028	"	29	"
	Like sex,	10 to 16 years,	r = .865 ± .027	"	38	"
		Difference	= .017 ± .038			
3.	Girl-Girl,	5 to 9 years,	r = .915 ± .026	"	19	"
	Girl-Girl,	10 to 16 years,	r = .814 ± .050	"	21	"
		Difference	= .101 ± .056			
4.	Boy-Boy,	5 to 9 years,	r = .800 ± .078	"	10	"
	Boy-Boy,	10 to 16 years,	r = .890 ± .034	"	17	"
		Difference	= .090 ± .085			
5.	Unlike Sex,	5 to 9 years,	r = .774 ± .064	"	18	"
	Unlike Sex,	10 to 16 years,	r = .298 ± .137	"	20	"
		Difference	= .476 ± .151			

As far as the effects of age on twin resemblance are concerned, the present study confirms the conclusions of Thorndike. For all twin pairs with ages ranging from 5 to 9 years, inclusive, the correlation is +.809. For pairs with ages 10 to 16 years, inclusive, the correlation is +.757. The difference .042 is scarcely more than the P.E. of either measure. The P.E. of this difference, .048, also shows that no statistical significance can be attached to the change in correlation. In the case of the like-sex pairs the change from the young to the old pairs is —.017; in the case of the boy-boy pairs +.090; and in the case of the girl-girl pairs —.101. In each case the P.E. of difference shows clearly that the slight change in correlation cannot be interpreted as indicating a difference in twin resemblance due to age. The results of the measures of the unlike sex pairs are not so clear. The drop from .774 to .298 is almost five times as great as is found in any other group. Three possible explanations present themselves. (1) Environment may actually operate to cause twins to grow more and more unlike. We have just seen, however, that environment has no such effect upon the other four groups studied. It is therefore reasonable to question the validity of this explanation and to look for some other explanation. (2) There may be inherited differences or likenesses that demand maturity to make them evident. This explanation, however, fails for the same reason that the first one did. Moreover, to accept this explanation would necessitate accepting the idea of a constantly changing I.Q. This is a debatable point, but the writer believes that the preponderance of available evidence is in favor of the theory that the I.Q. remains relatively constant. Again, to accept this explanation would necessitate showing why the change is a negative change rather than a positive one. (3) The change may be explained statistically in terms of the small population. That this explanation is probably the correct one, is suggested by two facts. The difference in correlation, .476, is scarcely more than three times the P.E. of the difference, .151. The best evidence, however, comes from the Beta and N.I.T. results which are to be shown later. For these tests the sharp contrast does not occur. It therefore seems reasonable to conclude that the statistical explanation is the most plausible one, and that as far as the Stanford-

Binet results are concerned there is no valid evidence that twin resemblance becomes greater the longer the identical environment lasts.

Table 3 shows the results of the Beta tests.

TABLE 3

1.	All pairs,	5 to 9 years,	r = .784 ± .049	with	28	pairs
	All pairs,	10 to 16 years,	r = .664 ± .054	"	48	"
		Difference	= .120 ± .072			
2.	Like sex,	5 to 9 years,	r = .921 ± .025	"	16	"
	Like sex,	10 to 16 years,	r = .842 ± .036	"	29	"
		Difference	= .079 ± .043			
3.	Girl-Girl,	5 to 9 years,	r = .709 ± .112	"	9	"
	Girl-Girl,	10 to 16 years,	r = .896 ± .032	"	16	"
		Difference	= .187 ± .116			
4.	Boy-Boy,	5 to 9 years,	r = .934 ± .049	"	7	"
	Boy-Boy,	10 to 16 years,	r = .747 ± .080	"	13	"
		Difference	= .087 ± .093			
5.	Unlike Sex,	5 to 9 years,	r = .519 ± .147	"	12	"
	Unlike Sex,	10 to 16 years,	r = .643 ± .091	"	19	"
		Difference	= .124 ± .172			

When the methods already used in the examination of the Stanford-Binet data are applied to the Beta data, the same conclusions are justified. The differences between the younger and the older groups are either very small or can be explained statistically without necessitating the assumption that environmental factors have been operative.

TABLE 4

1.	All pairs,	5 to 9 years,	r = .797 ± .034	with	54	pairs
	All pairs,	11 to 18 years,	r = .875 ± .017	"	89	"
		Difference	= .078 ± .038			
2.	Like Sex,	5 to 10 years,	r = .946 ± .012	"	31	"
	Like Sex,	11 to 18 years,	r = .865 ± .022	"	61	"
		Difference	= .081 ± .025			
3.	Girl-Girl,	5 to 10 years,	r = .965 ± .009	"	24	"
	Girl-Girl,	11 to 18 years,	r = .919 ± .021	"	37	"
		Difference	= .046 ± .022			
4.	Boy-Boy	5 to 10 years,	r = .921 ± .041	"	7	"
	Boy-Boy,	11 to 18 years,	r = .895 ± .027	"	24	"
		Difference	= .026 ± .049			
5.	Unlike Sex,	5 to 10 years,	r = .753 ± .066	"	23	"
	Unlike Sex,	11 to 18 years,	r = .834 ± .044	"	28	"
		Difference	= .081 ± .079			

Table 4 shows the results of the National tests. The reader will note that the age ranges are different from those in Tables 2 and 3. This change was made because the National Tests were not used below the third grade level.

We find that the conclusions drawn from Tables 2 and 3 are fully supported by the data in Table 4; there is no evidence of any age difference in the degree of resemblance.

Table 5 shows the results of the teacher ratings.

TABLE 5

1.	All pairs,	5 to 9 years,	$r = .686 \pm .057$	with	39	pairs
	All pairs,	10 to 16 years,	$r = .373 \pm .081$	"	51	"
		Difference	$= .313 \pm .099$			
2.	Like sex,	5 to 9 years,	$r = .788 \pm .053$	"	23	"
	Like sex,	10 to 16 years,	$r = .568 \pm .083$	"	30	"
		Difference	$= .220 \pm .098$			
3.	Girl-Girl,	5 to 9 years,	$r = .913 \pm .030$	"	14	"
	Girl-Girl,	10 to 16 years,	$r = .521 \pm .123$	"	16	"
		Difference	$= .392 \pm .126$			
4.	Boy-Boy,	5 to 9 years,	$r = .534 \pm .161$	"	9	"
	Boy-Boy,	10 to 16 years,	$r = .715 \pm .089$	"	14	"
		Difference	$= .181 \pm .184$			
5.	Unlike Sex,	5 to 9 years,	$r = .681 \pm .090$	"	16	"
	Unlike Sex,	10 to 16 years,	$r = .072 \pm .141$	"	21	"
		Difference	$= .609 \pm .167$			

It is not so easy to interpret the results shown in Table 5. The changes from .686 to .373 in the first group and from .788 to .568 in the second and from .913 to .521 in the third are too much to be attributed to the size of population. Since the three changes are in the same direction, and that towards less resemblance, the writer believes the explanation lies in the better acquaintance that the teachers have with the older children. Since the children resemble more or less in physical appearance, including dress, teachers have been compelled to seek for all the differences in terms of which they might know one member from another. As the children advance in the grades it becomes increasingly necessary for the teacher to be able to tell the children apart. It is therefore conceivable that this overemphasis on differences may operate to make the teacher rating a little less accurate for the older groups than for the younger. That this explanation may be correct is shown

by a study of the correlation between Binet I.Q. and teacher ratings.

For pairs 5 to 9 years old, $r = .593 \pm .05$,
For pairs 10 to 16 years old, $r = .536 \pm .05$.

When it is remembered that many studies have shown a correlation of approximately .60 between Stanford-Binet I.Q. and teacher ratings, it will be seen that the above explanation is at least plausible. As will be seen from a study of the differences and their P.E.'s the results for the other groups can be interpreted more easily in terms of small population. It is therefore to be concluded that while the results of Table 5 are not quite as convincing as were those of earlier tables, they may not indicate any serious disagreement with the results previously found.

THE INTELLECTUAL LEVEL OF A TWIN POPULATION

While the writer was collecting his data, he frequently met the questions: "Does not the general mental level of a twin group lie below that of the general population?" or, "Is there an intellectual handicap placed upon the individual who happens to be a twin?" The question is of sufficient interest to justify a brief examination of the present data.

Table 6 shows the Stanford-Binet I.Q. distribution of the 200 children composing the pairs with ages 5 to 14 inclusive, and Figure A shows the same data in comparison with Terman's study of 905 unselected children. In Fig A the frequencies are treated on the percentage basis.

TABLE 6

I.Q.	FREQUENCY
56- 65	4
66- 75	14
76- 85	28
86- 95	49
96-105	54
106-115	33
116-125	10
126-135	6
136-145	2
Total	200

It will be seen at once that there are some variations. The median for the twin group is 97. Terman reports the median for the 905 unselected children as 99. This difference of two points cannot be interpreted as showing twin inferiority, for other studies have shown some variation in median I.Q. For example, Pintner and Noble (*Journal of Educational Psychology,* November, 1920, p. 716) in reporting a study of 450 pupils in grades one to five inclusive, give a median I.Q. of 103 with an interquartile range of 22. On the other hand, Chase and Carpenter (*Journal of Educational Psychology,* April, 1919, pp. 179 ff.) in reporting the responses of a composite group with ages 9 to 12 inclusive give a

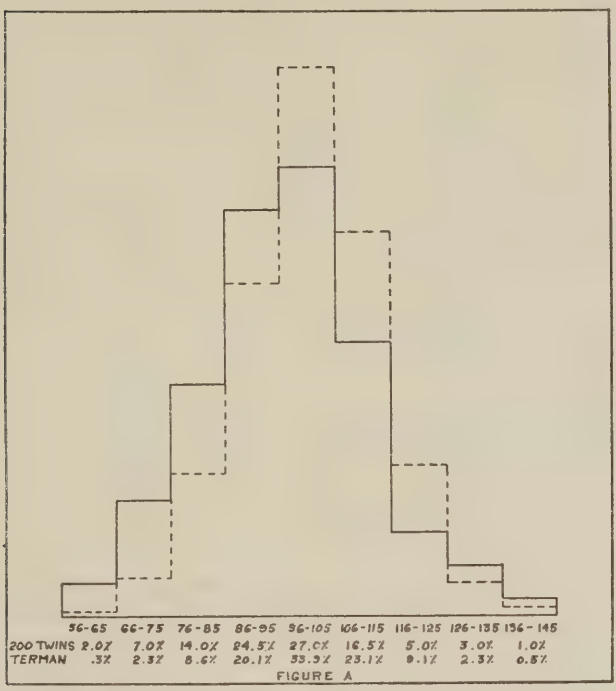


FIGURE A

The heavy line diagram shows the distribution of I. Q. for the 200 twins and the dotted line diagram shows the same for Terman's 905 unselected children.

median I.Q. of 92 and an interquartile range of 15. It is to be noted further that the twin interquartile range is 18, and that 905 children of Terman's study show an interquartile range of 17.7. If the twins of ages 6 to 11 inclusive are used, it will be found that they have a median I.Q. of 99.4. It is therefore concluded that these 200 twins show no greater departures from the normal than would many other groups of 200 non-twin individuals.

The above comparison is based upon just the 100 pairs falling within the age limits of 5 to 14 inclusive. This limitation was made in order to have the age range the same as the Terman study. This eliminated five pairs of ages above 14. Placing these back in our data and dividing our population into younger and older groups, by sex, we have the results shown in Table 7.

Examination of the above data confirms the earlier conclusion that no handicap obtains. There are some differences that appear

upon the surface: for example, the boy-boy pairs seem to excel the girl-girl pairs. This difference can be accounted for by the fact that the low girl-girl score is caused by the rather extreme retardation of a very small number of the older girls. As the Stanford-

TABLE 7

TYPE OF GROUP	NUMBER IN GROUP	AVERAGE I.Q.
All Twin Pairs	105	96
Pairs 5 to 9 years old	47	99
Pairs 10 to 16 years old	58	94
Like Sex Pairs	67	97
Like Sex 5 to 9 years old	29	99
Like Sex 10 to 16 years old	38	95
Unlike Sex Pairs	38	95
Unlike Sex 5 to 9 years old	18	98
Unlike Sex 10 to 16 years old	20	92
Girl-Girl Pairs	40	94
Girl-Girl 5 to 9 years old	19	99
Girl-Girl 10 to 16 years old	21	90
Boy-Boy Pairs	27	100
Boy-Boy 5 to 9 years old	10	99
Boy-Boy 10 to 16 years old	17	101
Boys of Unlike Sex Pairs	38	95
Girls of Unlike Sex Pairs	38	95
Total Boys—all pairs	92	96.9
Total Girls—all pairs	118	94.4

Binet is known to measure a little low for the upper ages, it is to be expected then that the younger groups would show a slight superiority over the older in the test scores. The average of the boys in the unlike sex pairs is exactly the same as the average for the girls of the unlike sex pairs. The small difference between total boys and total girls can be accounted for by the relatively larger number of retarded girls in the older group. It is therefore to be concluded that the present data show no handicap placed upon the members of a twin population.

The question of the relative variability of the sexes brings up still another aspect of our problem. Table 8 shows the Stanford-Binet I. Q. distribution for the boys of all pairs vs. the girls of all pairs.

Examination of these results will show that the boys seem to be slightly ahead of the girls on most of the items, the widest de-

TABLE 8

Binet I.Q. Distribution of Boys vs. Girls

I.Q.	BOYS	GIRLS
56- 65	0	4
66- 75	5	11
76- 85	14	17
86- 95	24	25
96-105	23	37
106-115	15	17
116-125	6	4
126-135	3	3
136-145	2	0
Total	92	118
Mean =	98.5	94.8
Median =	97.3	96.5
$Q_{.1}$ =	87.6	84.5
$Q_{.3}$ =	108.0	104.5
$Q_{.3} - Q_{.1}$ =	20.4	20.0
σ =	15.3	15.1
Variability =	15.5	15.9

parture being in the mean. On the other hand, the variability of the girls slightly exceeds the boys. That there may be a selection factor operating to produce a part of this difference is suggested by a little study of the scores made by the older children. In the 15-16 year old group, there are 8 scores that lie below 96. Four of these were made by boys and four by girls. Three of the boy scores lie between 86 and 96 and one between 66 and 76. Three of the girl scores lie between 76 and 86 and one between 66 and 76. If these eight scores are dropped, the following results are obtained:

	88 BOYS	114 GIRLS
Mean	98.1	95.3
σ	15.5	15.0
V	15.8	15.7

This brings the variability practically together and seems to suggest that there are no outstanding differences in favor of either sex.

It is not the purpose of this study to determine the relative sex variability in a general population. At the present time this is a very debated point. A few studies have shown slight advantages for the boys. Others have indicated greater variability for the girls. Still others have shown little if any sex differences. The data here presented show such slight differences, that the writer is con-

vinced that whatever is finally found to be the case with a general population, will likewise be the case with a large twin population.

The answer to the question asked at the beginning of this part of the study, therefore, is, that there is no intellectual handicap placed upon an individual who happens to be a twin.

RELATION TO BIOLOGY

It is necessary to make clear the meaning that is to be given to certain terms that will frequently occur in this part of the study. The following are the usual definitions of the terms "siblings," "fraternal twins," and "duplicate or identical twins":

1. Siblings. Children of the same parents, the mode of birth being the single birth. May be brother-brother, sister-sister, or brother-sister relationship.
2. Fraternal Twins. May or may not be of the same sex, are usually no more alike than are ordinary brothers and sisters, and are believed to be derived from two fertilized eggs.
3. Duplicate or Identical Twins. Always of the same sex, are almost identical, and are believed to be derived from a single fertilized egg.

It is evident that these definitions are built upon a certain assumption: viz. that there are two distinct kinds of twins, and that in some way these two kinds are determined by the mode of origin. It is also clear that the matter of sex plays a very fundamental part in this classification. That all authorities do not agree upon this may be brought out by a survey of some typical quotations.

> "The evidence in the case of the thirty-nine pairs of twins from whom we have extended physical measurements gives no reason for acceptance of the hypothesis of two such distinct groups of twins." (Thorndike, Measurement of Twins, 1905, p. 44.)

> "In animals also there is much evidence, aside from that afforded by the chromosomes, to be discussed below, in favor of the view that sex is internally controlled. . . . In the nine-banded Armadillo (Newman and Patterson, 1909, 1910) one fertilized egg commonly gives rise to four new individuals, and the four are invariably all male or all female. Analogous instances of polyembryony are also known in insects. Human twins, if 'identical' (produced by the same egg), are invariably

of the same sex; if 'fraternal' (produced by different eggs) they may or may not be of the same sex. It would therefore seem that sex in such cases as these must be determined either in the egg before fertilization or at the moment fertilization occurs." (Sharp, Introduction to Cytology, 1921, p. 357.)

"Resemblance will depend upon the identity of the hereditary primary constituents, on the similar combination of the germ plasm. Man himself affords a particularly good example in favour of this interpretation in the case of so-called 'identical twins.' It is well known that there are two kinds of twins, those that are not strikingly alike, and often very different, and those that are alike to the extent of being mistaken for one another. Among the latter the resemblance may go so far that the parents find it necessary to mark the children by some outward sign, so that they may not be continually confused. We have now every reason to believe that twins of the former kind are derived from two different ova, and that those of the latter kind arise from a single ovum, which, after fertilization, has divided into two ova." (Weismann, The Evolution Theory, 1904. Vol. II, pp. 44-45).

"It is known that there are two sorts of twins. (1) The true or 'identical' twins are developed from a single original egg cell which at some very early stage divided to form two individual beings. These 'identical' or 'duplicate' twins have a nearly (though never an absolutely) identical germ plasm, are always of the same sex and resemble each other to an extraordinary degree. (2) The other kind 'Fraternal' twins are no more alike than brothers and sisters born at different times. They are developed from two separate egg cells." (*The Journal of Heredity,* October 1918, p. 262.)

"Unlikeness in sex does not imply very much less difference in mental traits than that manifested by twins of the same sex." (Thorndike, Measurement of Twins, 1905, p. 33.)

"Biologists have for some time recognized at least two distinct types of human twins: fraternal and duplicate." (H. H. Newman, Biology of Twins, 1917, p. 8.)

"As is well known, twins are of two types: namely, those which are derived from two eggs ovulated simultaneously or nearly so, and those derived from a single egg which has formed two embryos." (C. B. Davenport, Influence of the Male on the

Production of Twins. In *Medical Record* for March 27, 1920.)

There can be no doubt that a clear cut issue is raised. Thorndike can find no evidence to support the theory that there are the two distinct kinds of twins. Newman, Davenport and many others are just as certain that the classification is sound. It will therefore be the purpose of this part of the study to assemble all the evidence that can be obtained from the present data bearing on the question.

The Biological Evidence

It is probable that some of the earliest theories of twinning must have grown out of the observation of such twin births as are illustrated by the Siamese twins. It would be natural to assume that their origin would in some way be different from the normal single birth. Add to this the comparatively recent development of the study of cell growth and division, and we have the setting for some kind of cell-division theory to explain the occurrence of twin births. We should also include in the list of contributing factors three other forces that certainly have operated to some extent to build up the present body of knowledge. There is the deep interest in the mechanism of heredity that has come as a result of the work of Weismann, Lamarck, Mendel, and others. There is the vast development of the use of statistics in all sorts of research. There is, in the third place, the interest in health and vital statistics. This last has impelled some of the leading nations to keep very elaborate birth and obstetrical records. It is from some of these last fields that much of the very convincing evidence has been obtained for the biology of twins. To illustrate this let us examine facts regarding the sex ratios of twins.

On the supposition that twins originate always from two separately fertilized ova, and that it is a mere matter of chance whether an individual of a pair of twins is to be male or female, one can figure out the ratio that should obtain. This ratio would be 1 : 2 : 1. That is, there should be one pair of boys, to two mixed pairs, to one pair of girls. Let us see how this works out in actual life.

Since in each of these studies the sex ratio turns out to be approximately 1 : 1 : 1, there must be some other method of origin,

	SEX OF PAIRS		
	MALE	MIXED	FEMALE
Frequency of occurrence	234,497	264,098	219,312
Approximate ratio[a]	.88	1.00	.83

(H. H. Newman, Biology of Twins, page 9. Quoted from Nichols.)

	SEX		
	MALE	MIXED	FEMALE
Frequency of occurrence	1,118	1,193	1,023
Approximate ratio[a]	.93	1.00	.87

(Margaret V. Cobb: Evidence bearing on the origin of human twins from a single ovum, Science, Vol. 41, page 501.)

since the above assumed method of origin would give a ratio of 1 : 2 : 1. Biologists have argued from the Nichols data as given above to the conclusion that a part of the like-sex pairs must be of one-egg origin. This argument runs as follows:

	MALE	MIXED	FEMALE
1. Frequency of occurrence	234,497	264,098	219,312
2. Approximate ratio	1	1	1
3. But if all twins are of two-egg origin, and sex is determined at time of fertilization, the ratio should be	1	2	1
4. That is, by law of chance, on basis of mixed pairs, we should have	132,049	264,098	132,049
5. This gives excess of	102,448	.....	87,263

[a] Note: In the original the approximate ratio is given as 1 : 1 : 1. The writer has calculated to second decimal as above.

If these two numbers are combined it gives a total like-sex pair excess of 189,711. When this is compared with the total number given by Nichols, 717,907, it is seen that the ratio is approximately one-fourth. Nichols and Newman therefore conclude that about one-fourth of all twin births will be of the one-egg or duplicate type.

The same method of treatment applied to the Cobb data gives substantially the same results. Miss Cobb does not use the terms fraternal and duplicate, but she does say that 28.4% of the pairs reported by her were presumably of the uni-ovular origin.

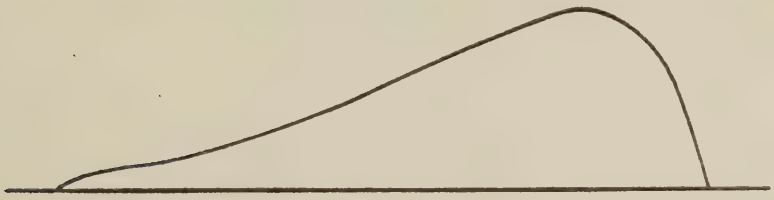
French and German statistics on obstetrics (quoted by Danforth in *Journal of Heredity*, Vol. VII, p. 195 ff.) say 15% of twins are of uni-ovular origin. These figures are based upon the assumption that one can tell the origin by an examination of the membranes that enclose the child. It has been pretty conclusively shown that the single-membrane test is not infallible as a sign of single-egg origin. There have been cases of fused membranes

which appear to be single, but are actually double. Many obstetricians also report the reverse condition: viz., multiple membrane, but one-egg origin. When allowance is made for these varying factors, the French and German figures probably come very close to the figures previously quoted from Newman and Cobb.

It does not fall within the province of this study to go extensively into the literature of sex determination. For the data on this one must go to the work of Morgan, Doncaster, Bateson, *et al.* The evidence supports the theory that sex is determined at the time of fertilization and before the division of the cell. The bearing of the last statement upon the problem of twin origin is very important, since the whole explanation of the statistics noted above is based upon it.

The arguments against the existence of two distinct types of twins center largely about the work of two men, Thorndike in America and Fisher in England. Thorndike approaches the matter wholly from the statistical angle, and submits a skewed unimodal curve as a summary of his argument.

> "The form of distribution of twin resemblance is apparently of the somewhat common type where a trait is very variable and has its mode close to an absolute limit of some sort. With all



> discretion in interpretation, however, one may be sure of (1) the general existence of close resemblance as the most frequent fact. (2) An extreme variability toward low resemblance, or even greater unlikeness than exists between two unrelated individuals of the same sex and age, and (3) the absence of any sharp break into two species of resemblance." (Thorndike, "Measurement of Twins," p. 50).

It is this last fact that stands out for Thorndike, and upon which he bases his conclusion that there are not two distinct kinds of twins.

Fisher in England made a further study of the problem, using Thorndike's data. He accepted the unimodal skewed curve as representative of the resemblance that exists between twin pairs. In discussing the cause for this type of distribution he says: "The fact that the observations examined critically show themselves to be a strictly homogeneous population, with correlation much larger than that between sibs, requires a new theory of the genetic connection between twins. It is here suggested that the facts may be explained by the supposition that twins ordinarily share the hereditary nature of one gamete but not of the other." (R. A. Fisher, "The Genesis of Twins," *Genetics,* September, 1919, p. 496). On page 498 he further says: "If we suppose that in certain cases the ovum after maturation is induced to divide into two identical portions, which are fertilized by different spermatozoa, not only is the observed resemblance of twins numerically explained, but the influence of the father is open to reasonable explanation."

The foregoing quotations show very clearly that there is no agreement in the outcome of the various lines of thinking. The biologists are pretty generally agreed that there are two distinct types of twins. Thorndike and Fisher, on the other hand, hold that there are not two distinct classes and that all the peculiarities of the resemblance curve can be explained in terms of a homogeneity of population, and that the phenomenon of sex determination is related in some way to the maturity of the ovum. The crucial question then becomes one of determining whether a twin population is heterogeneous or homogeneous. Do the psychological data of the present study throw any light on this question?

The Proposed Argument

Since the "two distinct species" theory is the more widely accepted, let us assume that it is the correct theory and then list the principal claims that it makes, and the results that should follow. Having done this we can proceed to the examination of the data in hand to see how it confirms or rejects the claims made.

1. There are two distinct types of twins, fraternal and duplicate.
2. The fraternal, being of the two-egg origin, should show no greater resemblance than ordinary siblings, since each indi-

vidual of the pair develops from a wholly independent arrangement of the factors for heredity in the germ cells.

3. The duplicate, being of the one-egg origin, should show a very much higher degree of resemblance than the fraternal because each member of the pair develops from substantially the same arrangement of the factors for heredity in the germ cells.
4. One of the real difficulties of the problem arises from the effort to tell whether a given pair belongs to the fraternal or duplicate type. Some have attempted to do this in terms of general resemblance of hair, eyes, facial features, etc. Others have sought to get away from the subjective factor involved in this method by using fingerprints, sole-prints, etc. These methods have not proven entirely satisfactory. There is, however, one factor which stands unchallenged, and that is the sex-factor. Since sex is determined at the time of fertilization the duplicate twins must always be of the same sex. A crucial test of the theory will then be in the determination of the resemblance of like-sex versus unlike-sex pairs. The resemblance in the former case should run materially higher.
5. This suggests the next difficulty. The group of like-sex pairs must by the law of chance contain a considerable number of fraternal twins. It was stated previously that about one-fourth of all twins are of the duplicate type. Since the like-sex pairs constitute roughly two-thirds of the number of pairs, then the number of duplicate pairs should approximate three-eights of the like-sex pairs. The differences, then, between the resemblance curve of the unlike-sex pairs and the like-sex curve must be accounted for by the fact that approximately three-eighths of the group belong to the duplicate type of twin.

The foregoing claims clearly show that we must make at least four attacks upon the data:

1. What is the degree of resemblance shown by siblings?
2. What is the degree of resemblance shown by unlike-sex pairs? How does this compare with the sibling results?
3. What is the degree of resemblance shown by like-sex pairs?

How does this compare with the sibling and unlike-sex pair results? How does this bear upon the claim that there are two distinct types of twins?

4. Do the present data lend themselves to such treatment that we can specify what particular group of like sex-pairs constitute the duplicate group?

Sibling Data

It was stated above that the coefficient of resemblance with siblings would furnish a valid check on our conclusions with reference to fraternal twins. The writer has assembled sibling data from various sources and submits the following as typical:

(1) From an unpublished study by Miss Grace Rensch, Stanford University.

Palo Alto	167 cases	I.Q. $r = + .48 \pm .046$
San Jose Normal	61 cases	I.Q. $r = + .57 \pm .071$
Palo Alto,	189 cases (paired)	I.Q. $r = + .61 \pm .035$
San Jose Normal	79 cases (paired)	I.Q. $r = + .51 \pm .060$
Palo Alto, Sister-Sister	82 cases	I.Q. $r = + .51 \pm .060$
Palo Alto, Brother-Brother	105 cases	I.Q. $r = + .40 \pm .056$
Palo Alto, Brother-Sister	164 cases	I.Q. $r = + .34 \pm .050$

Average $r = + .49$

(2) From Karl Pearson, Biometrika, Vol. III (1904).

On the Laws of Mental Inheritance in Man

	BROTHERS	$r = .64$	$r = .63$
Vivacity	$r = .47$	$r = .49$	$r = .51$
Self-Assertiveness	$r = .53$	$r = .47$	$r = .44$
Introspection	$r = .59$	$r = .56$	$r = .48$
Popularity	$r = .50$	$r = .61$	$r = .52$
Conscientiousness	$r = .59$	SISTERS	BROTHERS AND SISTERS
Temper	$r = .51$	$r = .43$	$r = .49$
Ability	$r = .46$	$r = .44$	$r = .52$
Handwriting	$r = .53$	$r = .47$	$r = .63$
Average	$r = .52$	$r = .57$	$r = .49$

General Average $r = .52$

Many other studies have been made along similar lines. Some of these deal with mental traits and abilities. Others deal with strictly physical measurements. The fact to be remembered from all these studies is that sibling resemblance is universally stated to be very close to $r = +.50$. None of the studies report significant variations from this figure.

The second question raised above has to do with the resemblance

of unlike-sex pairs, and its relation to the resemblance shown by siblings. The following shows the results of this part of the study:

RESEMBLANCE OF UNLIKE-SEX PAIRS

1.	Stanford-Binet	$r = .504 \pm .081$	38 cases
2.	Army Beta	$r = .732 \pm .056$	31 cases
3.	N. I. T.	$r = .867 \pm .025$	51 cases
4.	Teacher estimate	$r = .266 \pm .102$	37 cases

These figures furnish convincing evidence for the relation between fraternal twins and siblings. It was said in an earlier connection that fraternal twins are siblings as far as heredity is concerned. We have just seen that the sibling resemblance runs close to the $r = +.50$ mark, and the present figures for unlike-sex pair twins, especially the Stanford-Binet scores, give practically the same amount, ($r = .504$). The Beta Figure ($r = .732$) and the N.I.T. ($r = .867$) are above the theoretical .50, and the Teacher estimate ($r = .266$) is below the expectation. At first thought these departures would seem to argue against our thesis. When these figures are compared with the figures for the like-sex pairs it will be seen that there is a plausible explanation for the apparent disagreement. Let us therefore turn to that comparison.

The following figures show very plainly that there is a difference between the like-sex group and the unlike-sex group.

LIKE-SEX VERSUS UNLIKE-SEX PAIRS

Stanford-Binet

Like-sex	$r = .867 \pm .020$	67 cases
Unlike-sex	$r = .504 \pm .081$	38 cases
	Difference $= .363 \pm .083$	

Beta

Like-sex	$r = .908 \pm .017$	45 cases
Unlike-sex	$r = .732 \pm .056$	31 cases
	Difference $= .176 \pm .058$	

N. I. T.

Like-sex	$r = .925 \pm .009$	92 cases
Unlike-sex	$r = .867 \pm .025$	51 cases
	Difference $= .058 \pm .026$	

Teacher

Like-sex	$r = .654 \pm .053$	53 cases
Unlike-Sex	$r = .266 \pm .102$	37 cases
	Difference $= .388 \pm .114$	

Since it was pointed out in the proposed argument that this would be a vital point, let us examine these results more in detail.

In the Binet results the like-sex resemblance is .867 while the unlike-sex resemblance is .504. This is a difference of .363 ± .083 in favor of the like-sex groups. The Beta resemblance shows a difference of .176 ± .058 in favor of the like-sex groups. The N.I.T. difference of .058 ± .026 is not as large as the others, but since the difference is in favor of the like-sex pairs, and since a small difference between high r values may be quite significant, it can hardly be argued that the N.I.T. evidence contradicts the Binet and Beta evidence. The teacher rating results show a difference of .388 ± .114 in favor of the like-sex groups. All of the evidence thus far, therefore, supports the biological claim that there are two distinct kinds of twins.

This conclusion was reached by a study of resemblance in terms of correlation coefficients. There is still another way in which the same data can be treated, viz., in terms of differences in gross scores. Largely because of the size of population available, this part of the study will be based upon the Stanford-Binet I.Q. and the National Scores.

Table 9 gives the distribution of arithmetical difference in Binet I.Q. scores for the four groups studied.

The data of Table 9 can be studied in two different ways. First, we can calculate the mean I.Q. difference for certain types of population. The difference between these means will be a measure of the homogeneity of population. The results of this plan of attack are as follows:

Mean I.Q. difference, unlike-sex pairs = 9.52 ± .85
Mean I.Q. difference, like-sex pairs = 6.05 ± .45
Difference = 3.47 ± .96

Since the difference is 3.6 times its P.E. the evidence from this direction favors the theory that we have to deal with two types of population.

The data of Table 9 may also be treated graphically as shown in Figure B. It is seen at a glance that there is a decided difference in the types of curves. The siblings and unlike-sex curves resemble in a general way. Each starts with a low frequency for zero differences in I.Q. This agreement seems to lend some graphic proof for the biological claim that unlike-sex twins have the two-egg

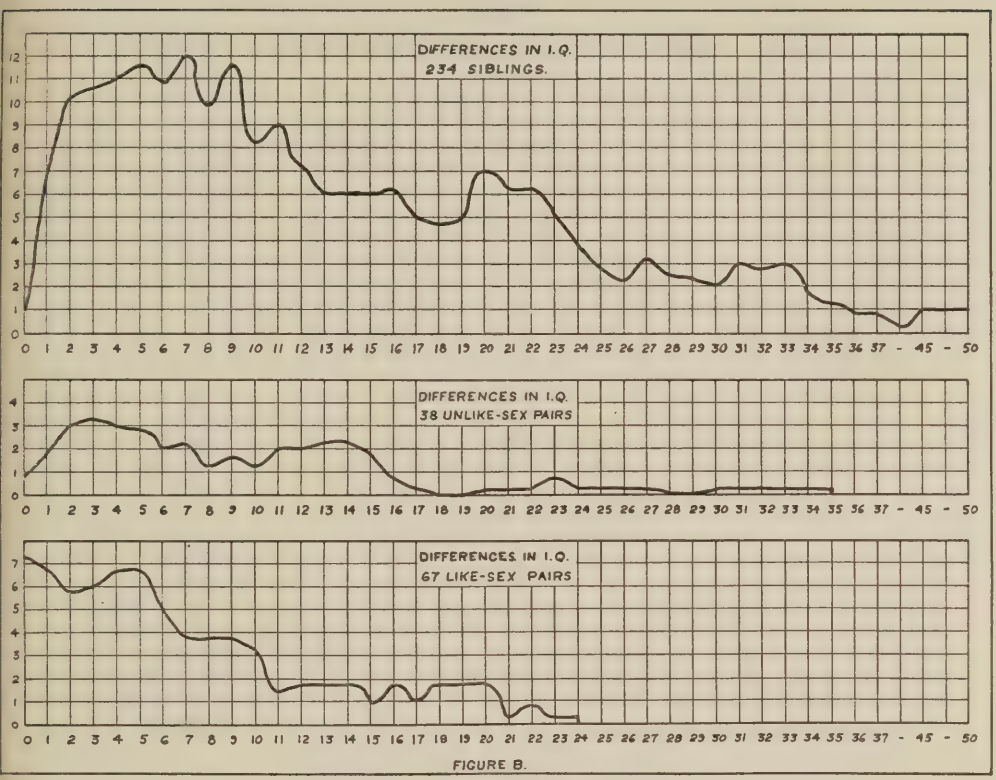


FIGURE B.

origin in the same manner that siblings have. On the other hand the like-sex curve starts with its highest frequency for zero differences. This would seem to conform to the biological claim for "duplicate" twins.

Similar facts are revealed by the N.I.T. data, as shown in Figure C. There is one difference to be noted in the construction of the curves of Figures B and C. In Fig. B the separate scores are plotted. In Fig. C, the scores are grouped as indicated at the bottom of the figure. This was done for two reasons. In the first place the score range for the N.I.T. data is much greater than for the Stanford-Binet. The relative frequencies are therefore smaller and it becomes difficult to see the form of the curve. In the second place, it is necessary in a later part of the study to use the grouped

TABLE 9

DIFF.	ALL PAIRS	LIKE-SEX	UNLIKE-SEX	SIBLINGS
0	9	8	1	6
1	6	6	0	12
2	10	6	4	8
3	9	5	4	11
4	10	7	3	13
5	9	7	2	9
6	9	6	3	12
7	3	2	1	10
8	6	3	3	13
9	3	3	0	6
10	4	2	2	13
11	4	2	2	6
12	2	0	2	8
13	5	3	2	6
14	4	1	3	3
15	2	0	2	9
16	2	2	0	6
17	0	0	0	14
18	1	1	0	4
19	1	1	0	5
20	0	0	0	6
21	2	1	1	9
22	0	0	0	4
23	1	1	0	6
24	0	0	0	0
25	1	0	1	0
26	0	0	0	3
27	0	0	0	4
28	0	0	0	3
29	0	0	0	1
30	0	0	0	3
31	1	0	1)	
32	0	0	0)	
33	0	0	0)	13
34	1	0	1)	
40	0	0	0)	
41 to 50	0	0	0	2
	105	67	38	234

form of the data, and for convenience the same grouping is used at this time.

If this distinction in type of curve is a real one it should be shown by the tests that have been devised for homogeneity and curve fitting. The best test for this purpose that the writer has been able to find is found in the work of Karl Pearson and W. Palin Elderton who have published a formula and complete tables for testing curves where two separate populations are concerned. The formula and its method of use can be seen from the following

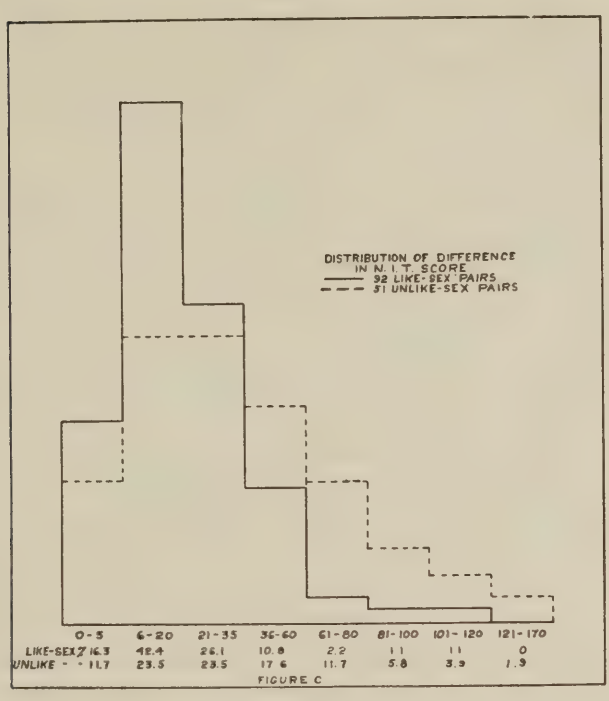


FIGURE C

quotation: "If N and N′ be the sizes of two samples and the corresponding frequencies:

$$f_1,\ f_2,\ f_3, \ldots\ldots f_p \ldots\ldots f_s$$
$$f'_1, f'_2, f'_3, \ldots\ldots f'_p \ldots\ldots f'_s$$

where f_p, f'_p are the frequencies falling in the p^{th} category, then if

$$X^2 = S^s_1 \left(\frac{NN' \left(\frac{f_p}{N} - \frac{f'_p}{N'} \right)^2}{f_p + f'_p} \right)$$

be calculated, the probability, P, that the observed or a greater divergence between the two series would arise from sampling the same population is obtained by determining P from X by my method of testing 'goodness of fit.' This method was first published in Phil. Mag. Vol. 50, p. 157, 1900. The shortest method of actually determining P is by aid of Palin Elderton's tables for P

with argument X^2 issued in Biometrika, Vol. I, p. 155, 1902." (Karl Pearson, Biometrika, Vol. 10, p. 92.)

The following pages (35-36) show the application of the Pearson formula and Elderton tables to the Stanford-Binet and National Intelligence Test data.

Since the S-B data show a probability of 27 to 1 that the populations are different, and since the N.I.T. data show a probability of 40 to 1 that they are different, it is clear that the biological claim for two distinct types of twins is strongly supported by the data on intellectual resemblances.

It was stated at the beginning of this study that the problem would be limited to intellectual resemblances. It is pertinent to ask, however, at this point what would be the result if physical resemblances were studied by the same methods that we have been using. Thorndike gives on page 43 the correlations for a number of such measurements but he gives only the correlations for the twin group as a whole. He makes no distinction between like-sex and unlike-sex groups. His gross measures are given, however, in table 8 on page 37. The writer took these measures and calculated the resemblance in height and cephalic index. The results are as follows:

		HEIGHT	CEPHALIC INDEX
a.	39 twin pairs	$r = .775$	$r = .760$
b.	9 unlike-sex pairs	$r = .609 \pm .176$	$r = .461 \pm .221$
c.	30 like-sex pairs	$r = .821 \pm .042$	$r = .800 \pm .045$

NOTE: a = Thorndike's computations; b and c = the writer's. In b and c, P. E. $= \frac{.6745\ (1-r^2)}{\sqrt{n-3}}$ on account of small population.

It is hard to explain the difference in resemblance by any other theory than that of a real difference on the basis of likeness of sex. It must be admitted of course that the small population of the unlike-sex group and the resulting large P.E. reduces the value of the results somewhat but they certainly are in substantial accord with the results of the study of intellectual resemblances.

Up to this point, the study has proceeded in terms of the entire group of like-sex versus unlike-sex pairs. The conclusions are quite definitely in favor of the two distinct classes. We can not be en-

CALCULATONS TO DETERMINE WHETHER TWO STANFORD-BINET DIFFERENCE DISTRIBUTIONS ARE SAMPLES FROM THE SAME POPULATION

		0-4	5-9	10-14	15-19	20-24	25-35		
Like-sex	(1)	32	21	7	4	3	0	f	67
Unlike-sex	(2)	12	9	11	2	1	3	f′	38
(1) + (2) =	(3)	44	30	18	6	4	3	f+f′	105
(1) ÷ 67 =	(4)	.4776	.3134	.1044	.0597	.0448	.0000	f/N	
(2) ÷ 38 =	(5)	.3158	.2368	.2894	.0526	.0263	.0788	f′/N′	
(4) − (5) =	(6)	.1618	.0766	−.1750	.0071	.0185	−.0788	f/N−f′/N′	
$(6)^2$ =	(7)	.02617924	.00586756	.03062500	.00005041	.00034225	.00620944	$(f/N-f'/N')^2$	
(7) ÷ (3) =	(8)	.000595	.000195	.001701	.000008	.000085	.002069	$(f/N-f'/N')^2/(f+f')$	
Σ(8) =	(9)						.004653		

$$\text{If} \quad X^2 = S^2_1 \left(\frac{NN' \left(\frac{f_p}{N} - \frac{f'_p}{N'} \right)^2}{f_p + f'_p} \right)$$

$$X^2 = NN' \times .004653$$
$$= 67 \times 38 \times .004653$$
$$= 11.84+$$

Whence by Elderton Tables P = .037342

or roughly 27 chances to 1 that two populations are different.

CALCULATIONS TO DETERMINE WHETHER TWO N. I. T. DIFFERENCE DISTRIBUTIONS ARE SAMPLES FROM THE SAME POPULATION

		0-5	6-20	21-35	36-60	61-80	81-100	101-120	121-170		
Like-sex	(1)	15	39	24	10	2	1	1	0	f	92
Unlike-sex	(2)	6	12	12	9	6	3	2	1	f′	51
(1)+(2)=	(3)	1	51	36	19	8	4	3	1	f+f′	143
(1)÷92 =	(4)	.1629	.4239	.2608	.1087	.0217	.0108	.0108	.0000	f/N	
(2)÷51 =	(5)	.1176	.2352	.2352	.1764	.1176	.0588	.0392	.0196	f′/N′	
(4)—(5)=	(6)	.0453	.1887	.0256	—.0677	—.0959	—.0480	—.0284	—.0196	f/N—f′/N′	
$(6)^2$ =	(7)	.00205209	.03560769	.00065536	.00458329	.00919681	.00230400	.00080656	.00038416	$(f/N—f'/N')^2$	
(7)÷(3)=	(8)	.00009771	.00069819	.00001820	.00024122	.00114960	.00057600	.00026885	.00038416	$(f/N—f'/N')^2/(f+f')$	
Σ(8) =	(9)								.00343393		

$$\text{If} \quad X^2 = S^2_1 \left(\frac{NN' \left(\frac{f_p}{N} - \frac{f'_p}{N'} \right)^2}{f_p + f'_p} \right)$$

$$X^2 = NN' \times .00343393$$
$$= 92 \times 51 \times .00343393$$
$$= 16.11 +$$

Whence by Elderton Tables P = .024

or roughly 40 chances to 1 that the populations are different.

tirely certain of this, however, until we have made a more intensive study of the resemblance of the various pairs. Thorndike's method of doing this is fully discussed on pages 45-46 of his monograph.

"Our problem is to measure accurately the resemblance found in each pair of twins, and so to ascertain the form of distribution of the group with respect to resemblances. Suppose, for instance, that of forty twins, we found twenty to resemble each other practically perfectly, the coefficients being: 92, 93, 94, 94, 94, 95, 95, 95, 95, 95, 96, 96, 96, 97, 97, 97, 97, 98, 99, and 99, and the other twenty to resemble each other as follows: 17, 18, 24, 29, 32, 37, 37, 38, 40, 41, 41, 41, 42, 42, 44, 45, 46, 46, 51, and 62. It would be clear that there were two distinct types of twins.

To measure accurately the resemblance of an individual pair is, however, very difficult. The most serviceable measure which I am able to devise for a single trait is the Pearson coefficient, using each individual twice in the calculation. That is, if the deviation measures are:

First member of pair 6,
Second member of pair 3,

$$\text{Then the } \Sigma xy = 18 + 18$$
$$\Sigma x^2 = 36 + 9$$
$$\Sigma y^2 = 9 + 36$$
$$\text{and } r = 36/45 = .80$$

The objections to this measure are that when both members of the pair are near the central type, it may misrepresent the real relationship and will be much distorted by accidental errors in the deviation measures of an individual. Thus, suppose that in a case where the variability of the trait is 10, two twins score —1 and —2. Their r as calculated will be —.80, but they are really very much more alike than this figure would lead us to think. Suppose by accidental error the first member scored —2 instead of —1; then their r is —1.00. Suppose him to score —1; the resemblance is —.80." (Thorndike, Measurement of Twins, pp. 45-46.)

Thorndike regarded these objections as of sufficient validity to warrant other interpretative calculations, briefly indicated in the following quotation: "For each pair in each trait is given the r,

the amount of deviation from the central tendency of that one of the twins who deviated from it most (this is given in each case as a multiple of the median deviation for the trait in question), and the difference between the two twins' measures (this is given in each case as a multiple of the median difference of all the twins in the trait in question)." (Measurement of Twins, pp. 48-49.)

These measures were all assembled in the form of a distribution table and Thorndike concluded, "There is no sign in any of these of a sharp separation into a group of 'duplicate' twins with r's approaching 1.00 and differences approaching 0, and a group of r's approaching 40 and differences centering around a point well above the median difference for twins." This conclusion is undoubtedly justified if the figures and distribution of his tables 13 and 14 are accepted without question. The writer cannot, however accept them without question. There is first the value of r when the twin measures are near the central tendency. There is in the second place the introduction of a subjective factor. On page 48 Thorndike speaks of interpreting or considering one measure in the light of certain other conditions, and in a footnote on page 49 he speaks of his method of correcting r's by adding certain amounts to the obtained r if its value lies between —1.00 and +.60. He also speaks of altering the correction somewhat in view of the amount of the deviation. How much this subjective factor is worth, the writer does not attempt to say, but its very presence raises the question of the validity of the results.

In the present study a different method of calculating the individual pair resemblance has been used. This method is believed to avoid the difficulties just pointed out. The formula used is a special adaptation of the Pearson product moment formula and is as follows:

$$r = 1 - \frac{(\text{Difference in scores})^2}{2 \text{ times } \sigma^2 \text{ of entire population}}$$

The derivation of this formula is briefly as follows:

$$\sigma_d^2 = \frac{\Sigma \left(\frac{x}{\sigma_x} - \frac{y}{\sigma_y} \right)^2}{N}$$

$$\text{Expanding } \sigma_d^2 = \frac{\Sigma x^2}{N} - \frac{\Sigma 2xy}{N\sigma_x\sigma_y} + \frac{\Sigma y^2}{N}$$

$$\text{But } \sigma_x^2 = \frac{\Sigma x^2}{N} \text{ and } \sigma_y^2 = \frac{\Sigma y^2}{N}$$

$$\text{Substituting } \sigma_d^2 = 1 - \frac{\Sigma 2xy}{N\sigma_x\sigma_y} + 1$$

$$\text{But } \frac{\Sigma 2xy}{N\sigma_x\sigma_y} = \frac{\Sigma 2xy}{N\sigma_x\sigma_y} = 2r$$

$$\therefore \quad \sigma_d^2 = 2 - 2r$$

$$\text{or } r = 1 - \frac{\sigma_d^2}{2}$$

In special case let D = difference in gross scores.

$$\text{Then } d = \frac{D}{\sigma}$$

$$\text{Multiply both sides by } \frac{\Sigma d}{N}, \quad \frac{\Sigma d^2}{N} = \frac{\Sigma \frac{(D)^2}{(\sigma)}}{N}$$

$$\text{Whence } \sigma_d^2 = 1/\sigma^2 \cdot \frac{\Sigma D^2}{N}$$

$$= 1/\sigma^2 \cdot \sigma_D^2$$

$$\text{Substituting } r = 1 - \frac{\sigma_D^2}{2\sigma^2}$$

$$\text{or in special case } r = 1 - \frac{(\text{Difference in scores})^2}{2 \text{ times } \sigma^2}$$

The following computation will show the contrast between the results according to the method used by Thorndike and the one here proposed. Suppose we have two twin pairs whose Stanford-Binet scores are for the first pair 97 and 100, and for the second pair 99 and 101. Let us suppose also that the mean score for a twin population is 98 and the standard deviation is 15. The comparative results will then be:

(1) By Thorndike method, r first pair = —.80 and r 2nd pair = +.60
(2) By proposed method, r first pair = +.98 and r 2nd pair = +.99

It is quite evident that a very substantial difference will be made in the distribution tables when such results are assembled. In the above instances, the —.80 and the +.60 will go into nearly opposite parts of the table or curve, while the +.98 and +.99 will lie near together. When it is remembered that the original scores were very nearly alike, the second alternative seems the more reasonable. It was noted above that Thorndike introduced a subjective factor. Since the present study is based upon a rigid use of the method as just stated, it is believed that the subjective factor is pretty completely eliminated.

Tables 12 and 13 show the results of the application of this formula to the Stanford-Binet data, and for comparative purposes to one item of the Thorndike physical measurements. The first three columns give the distribution of r's for all twin pairs, like-sex pairs, and unlike-sex pairs respectively, the calculations being based upon I.Q. differences. The last three columns give the corresponding data for calculations made from the original cephalic index measures as given by Thorndike on pages 37-39.

The outstanding fact shown by Table 12 is the more pronounced resemblance shown by the like-sex group. Of 67 pairs in this group 45 show a resemblance falling within the .90 to 1.00 range. In the unlike-sex group 17 out of 38 lie within the same range. It should be noted also that the cases of extreme negative correlation belong to the unlike-sex group. Table 13 shows the force of this argument more clearly. This table shows the distribution of the cases falling within the .90 to 1.00 range. If we accept the range of .99 and 1.00 as amounting to practical identity we find that 20 out of 45 pairs of like-sex pairs are practically identical, while but 5 out

TABLE 12

Distribution of Resemblance in Individual Pairs as Measured by

$$r = 1 - \frac{D^2}{2\sigma^2}$$

R	ALL TWINS I.Q.	LIKE SEX I.Q.	UNLIKE SEX I.Q.		ALL PAIRS CEPHALIC INDEX	LIKE SEX CEPHALIC INDEX	UNLIKE SEX CEPHALIC INDEX
Less than —.91	2		2				
—.90 to —.81	0						
—.80 to —.71	0						
—.70 to —.61	0						
—.60 to —.51	0						
—.50 to —.41	0				1	1	
—.40 to —.31	1		1		1		1
—.30 to —.21	0						
—.20 to —.11	1	1			1		1
—.10 to —.01	0						
—. 0 to +.09	2	1	1				
+.10 to +.19	0				1	1	
+.20 to +.29	2	2			2	1	1
+.30 to +.39	0				1	1	
+.40 to +.49	2	2			1	1	
+.50 to +.59	6	1	5		3	2	1
+.60 to +.69	7	3	4				
+.70 to +.79	8	4	4		2	2	
+.80 to +.89	12	8	4		4	4	
+.90 to +1.00	62	45	17		22	18	4
Total	105	67	38		39	31	8

TABLE 13

R	ALL TWINS I.Q.	LIKE SEX I.Q.	UNLIKE SEX I.Q.		ALL PAIRS CEPHALIC INDEX	LIKE SEX CEPHALIC INDEX	UNLIKE SEX CEPHALIC INDEX
.90							
.91							
.92	9	6	3		2	2	
.93							
.94					1		1
.95	9	7	2		1		1
.96					4	4	
.97	10	7	3		1	1	
.98	9	5	4		5	5	
.99	10	6	4		4	3	1
1.00	15	14	1		4	3	1
	62	45	17		22	18	4

of 17 unlike-sex pairs can be so regarded. The evidence that has just been cited from the Stanford-Binet part of the tables can be, in the main duplicated with reference to the cephalic index part of the tables.

One other consideration remains. Do the present data lend themselves to such treatment that we can specify what particular like-sex pairs make up the group of duplicate twins? In our study of the Stanford-Binet I.Q. differences it was stated that the peculiar shape of the curve was produced by the presence of approximately 25 duplicate pairs. When this study was first planned it was hoped that the internal evidence of the data might enable us to identify these pairs. The writer has, however, been unable to devise any method of studying the curves or the scores that will certainly point out the duplicate pairs. It is exceedingly interesting, however, to follow up certain evidence that is contained in the verbal reports

TABLE 14

SCORES AND SCORE DIFFERENCES OF THE PAIRS THAT WERE REPORTED AS SIMILAR

Pair	Binet I.Q.	Difference I.Q.	Teacher rating	Rating difference	Beta scores	Beta Difference	N.I.T. Scores	N.I.T. Difference
5	104— 96	8	2.3—2.2	.1	.....	....	.....	....
8	110—106	4	3.0—3.0	0.0	.....	....	.....	....
10	107—110	3	2.5—2.4	.1	25—18	7	.....	....
12	66— 62	4	3.7—3.6	.1	.....	....	.....	....
13	93— 93	0	3.1—3.1	0.0	7—16	9	.....	....
22	102—100	2	2.6—3.0	.4	.....	....	.....	....
28	102—102	0	2.9—2.7	.2	48—46	2	140—196	56
29	104—109	5	3.1—3.1	0.0	45—58	13	114—122	8
30	103— 96	7	3.0—3.0	0.0	37—44	7	48— 46	2
36	123—118	5	3.0—3.0	0.0	61—50	11	268—286	22
46	135—127	8	2.3—2.3	0.0	46—60	14	246—238	8
58	112—106	6	2.7—3.0	.3	74—72	2	250—232	18
76	67— 73	6	3.4—3.4	0.0	54—51	3	126—142	16
77	85— 85	0	2.4—2.4	0.0	51—63	12	.....	....
84	75— 72	3	2.7—3.1	.4	41—20	21	94—124	30
86	88—107	19	3.1—3.1	0.0	77—80	3	264—254	10
88	109—122	13	2.2—2.2	0.0	84—78	6	.....	....
94	104—103	1	3.0—3.0	0.0	80—78	2	296—296	0
95	98— 98	0	2.6—2.9	.3	74—69	5	298—320	22
100	80— 85	5	3.5—3.3	.2	67—81	4	.....	....
104	83— 83	0	3.2—3.3	.1	69—73	4	198—208	10
107	101—107	6	1.7—1.6	.1	82—85	3	.....	....
	R—+.986		R—+.940		R—+.887		R—+.987	

of the examiners. Each examiner was asked to report whether the members of the twin pair being studied resembled each other closely enough to frequently cause confusion of identity. Unfortunately not every examiner made this report, so the following study of the curve locations of the "reported similar" pairs is not as complete as it might be. Table 14 presents a summary of certain data that will be used in this part of the study.

Table 14 has been so arranged that it shows the identification number of each of the pairs that was reported similar, and in appropriate columns the various scores and score differences. These data can be studied from the point of view of the degree of resemblance shown by this group as compared with either the entire like-sex pair population or the entire twin population. It can also be studied from the standpoint of curve location for the various pairs under consideration.

We shall note the matter of resemblance first. The following comparison furnishes rather striking evidence for the real similarity of those that are reported "similar." Correlating by

$$R = 1 - \frac{6\Sigma D^2}{N\,(N^2 - 1)}$$

we have:

For Stanford-Binet I.Q. .....R = +.986
For Teacher Rating .....R = +.940
For Beta .....R = +.887
For N. I. T.....R = +.987

These are very high correlations. Not only are they high correlations, but with one exception they are materially higher than the results that were found in earlier parts of the study for the resemblance in the entire like-sex group or the entire twin population. These figures are shown in Table 15.

This gives an excess of resemblance in favor of the "reported similar" in every case when they are compared with the total twin pairs, and in all cases except Beta when compared with total like-sex pairs. It is to be noted also that there is a steady increase in the value of r as the fraternal pairs or "supposed to be fraternal" pairs are dropped from consideration.

TABLE 15

	STANFORD BINET		TEACHER RATING		BETA		N.I.T.	
	N	r	N	r	N	r	N	r
All twin pairs	105	.782	90	.512	76	.841	143	.891
All like-sex pairs	67	.867	53	.654	45	.908	92	.925
"Similar" like-sex pairs	22	.986	22	.940	18	.887	12	.987

For the discussion of curve location the reader must recall the facts presented in Table 9 and Figures B and C. It was there shown that the plotting of the score differences produced a highly skewed curve, the skew being towards a small score difference. If we define that portion of the Stanford-Binet curve which is produced by score differences of 0 to 5 inclusive as the "Binet upper level," and that portion of the N.I.T. curve which is produced by score differences of 0 to 20 inclusive as the "N.I.T. upper level," we can make the following observations:

1. Of the 22 pairs reported similar, 13 pairs are on the "Binet upper level."
5. In the entire twin population, 9 pairs have a Binet I.Q. score difference of 0 and are therefore on the Binet upper level. Eight of these are like-sex pairs, and of the 8 pairs 5 are in the group of "reported similar." No report as to similarity was received upon the other 3 pairs.
3. Of the 22 pairs reported similar, 12 pairs took the National. Eight of these are located on the "N.I.T. upper level."

GENERAL SUMMARY OF PURPOSES, DATA, AND RESULTS

1. *Purposes.* This study of the intellectual resemblance of twins has sought to answer three questions:
   a) What is the effect of environment upon the amount of intellectual resemblance of twins?
   b) Does the fact of twin origin and birth operate in any way to lower the intellectual level of a twin population?
   c) What light do the psychological data throw upon the current biological belief that there are two distinct types of twins, fraternal and duplicate?
2. *Data.* Individual and group material was collected as follows:

Stanford-Binet tests for	105 pairs
Teacher estimates for	90 pairs
Army Beta tests for	76 pairs
National Intelligence tests for	143 pairs

3. *Treatment of Data.* These data were studied from many different angles. Young pairs were compared with old pairs. Like-sex pairs were compared with unlike-sex pairs. Boys were compared with girls, etc., etc. In making these various comparisons four methods of treatment were used:
   a) Pearson correlations between various groups.
   b) Difference in gross scores.
   c) Curve plotting and fitting to determine character of population.
   d) Empirical study of correspondence between psychological data and judgment of friends as to the resemblance of certain pairs.
4. *Findings.* The results of the study are presented in the form of answers to the three questions asked at the outset. For convenience, all the correlation results are assembled in Table 16. The reader will find it very helpful to refer frequently to this summary.

a) Environment appears to make no significant difference in the amount of twin resemblance. Table 16 shows twenty pairs of correlations on the basis of young twin pairs versus old twin pairs. Of these twenty pairs there are 15 that show either very slight changes or changes that can be explained on the basis of small population. The larger changes of the teacher rating comparisons are explained on the basis of better acquaintance with the older pairs and over emphasis of slight differences.

b) Twins suffer no intellectual handicap. This is shown in various ways:
   1) Mean and median I.Q. practically same as for general population.
   2) Mental level of boys same as girls.
   3) Like-sex pairs same mental level as unlike-sex pairs.
   4) No significant differences in variability of sexes.
   5) Young pairs show slightly higher mental level but this is explained by the fact that Stanford-Binet is more difficult for older children.

c) The data show quite conclusively that there are two distinct types of twins. This is shown in various ways:
   1) In every case where like-sex pairs are compared with unlike-sex pairs, the correlation of the like-sex pairs is significantly higher. Table 16 shows in groups 2 and 5 the twenty-four correlations that provide the evidence for the statement just made.
   2) When sibling data are compared with twin data, the correlations lie much nearer the unlike-sex pair twin data than to the like-sex pair data. This is in harmony with the biological claim that genetically speaking fraternal twins are siblings.
   3) All the curves and curve fitting tests used in the study indicate clearly a difference between like and unlike-sex pair twins.
   4) The empirical study of verbal reports on "similar pairs" tends strongly to show that curve differences are to be largely accounted for by the like-sex pairs that

show great intellectual and physical similarity, and that presumably belong to the "duplicate" type.

TABLE 16

SUMMARY OF CORRELATIONS

	BINET		BETA		N.I.T.		TEACHER	
	r	N	r	N	r	N	r	N
All twin pairs	.782±.025	105	.841±.022	76	.891±.011	143	.512±.053	90
Pairs, 5 to 9 yrs.	.809±.032	47	.784±.049	28	.797±.034	54	.686±.057	39
Pairs, 10 to 16 yrs.	.757±.037	58	.664±.054	48	.875±.017	89	.373±.081	51
Like-sex pairs	.867±.020	67	.908±.017	45	.925±.009	92	.654±.053	53
Like-sex 5 to 9	.882±.028	29	.921±.025	16	.946±.012	31	.788±.053	23
Like-sex 10 to 16	.865±.027	38	.842±.036	29	.865±.022	61	.568±.083	30
Girl-girl pairs	.857±.029	40	.866±.033	25	.928±.012	61	.645±.071	31
Girl-girl 5 to 9	.915±.026	19	.709±.112	9	.965±.009	24	.913±.030	14
Girl-girl 10 to 16	.814±.050	21	.896±.032	16	.919±.021	37	.521±.123	16
Boy-boy pairs	.877±.030	27	.938±.015	20	.925±.018	31	.605±.090	23
Boy-boy 5 to 9	.800±.078	10	.934±.049	7	.921±.041	7	.534±.161	9
Boy-boy 10 to 16	.890±.034	17	.747±.080	13	.895±.027	24	.715±.089	14
Unlike-sex pairs	.504±.081	38	.732±.056	31	.867±.025	51	.266±.102	37
Unlike-sex 5 to 9	.774±.064	18	.519±.147	12	.753±.066	23	.681±.090	16
Unlike-sex 10 to 16	.298±.137	20	.643±.091	19	.834 .044	28	.072±.141	21

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APPENDIX A

Gross Scores for Various Items

		SEX	GRADE	C.A.	M.A.	I.Q.	TEACHER	BETA	N.I.T.
Pair	1	F	..	5-10	6- 6	112	...	..	..
		F	..	5-10	6- 8	114	...	..	..
Pair	2	M	2b	6-11	7- 6	108	1.5	39	56
		F	2b	6-11	7- 4	106	2.2	45	88
Pair	3	M	1b	6- 3	6- 4	101	2.7	32	..
		M	1b	6- 3	5- 4	85	3.3	30	..
Pair	4	M	1a	6- 5	6-10	107	3.0	..	..
		F	1a	6- 5	7- 6	117	3.0	..	..
Pair	5	F	1a	6- 7	6- 4	96	2.7	..	..
		F	1a	6- 7	6-10	104	2.6	..	..
Pair	6	M	1a	6- 1	5- 6	90	3.7	..	..
		F	1a	6- 1	6- 0	98	2.7	..	..
Pair	7	F	1b	6- 0	6- 2	102	...	..	..
		F	1b	6- 0	5- 8	94	...	..	..
Pair	8	M	1b	6- 5	7- 1	110	3.2	..	..
		M	1b	6- 5	6-10	106	3.1	..	..
Pair	9	M	1b	6- 4	6-10	107	2.5	..	..
		F	1b	6- 4	6- 6	102	2.0	..	..
Pair	10	M	1a	6-10	7- 4	107	2.5	25	..
		M	1a	6-10	7- 6	110	2.4	18	..
Pair	11	M	2a	7-11	7-11	100	3.4	..	..
		F	2a	7-11	8- 0	103	2.8	..	..
Pair	12	F	1a	7-10	5- 2	66	4.1	..	..
		F	2b	7-10	4-10	62	4.5	..	..
Pair	13	M	1a	7- 4	6-10	93	3.1	..	..
		M	1a	7- 4	6-10	93	3.4	..	..
Pair	14	M	2a	7-10	7- 2	91	3.4	43	128
		F	2a	7-10	6- 0	77	3.3	38	108
Pair	15	M	2b	7- 6	7- 8	102	2.8	23	..
		M	2b	7- 6	7-10	104	2.5	23	..
Pair	16	F	1a	7- 3	7- 2	99	2.9	25	..
		F	1a	7- 3	7- 0	97	2.7	28	..
Pair	17	M	2a	7- 7	7- 8	101	2.6	51	..
		F	2b	7- 7	7- 8	101	3.1	50	..
Pair	18	M	1a	7- 5	6- 3	84	...	21	..
		F	1a	7- 5	6- 7	88	...	19	..
Pair	19	M	1b	7-10	7- 7	97	...	..	..
		F	1a	7-10	8- 6	109	...	..	..
Pair	20	M	2b	7- 6	7-10	104	...	..	..
		M	2b	7- 6	8- 8	115	...	..	..

	SEX	GRADE	C.A.	M.A.	I.Q.	TEACHER	BETA	N.I.T.
Pair 21	M	1b	7- 0	6- 0	86	3.8	2	..
	M	1b	7- 0	5- 6	79	3.4	12	..
Pair 113	F	3	7-10	....	...	...	..	143
	F	3	7-10	....	...	...	..	134
Pair 22	F	2a	8- 2	8- 2	100	2.3	..	...
	F	2a	8- 2	8- 4	102	2.0	..	...
Pair 23	F	4b	8- 8	9- 4	107	2.1	53	144
	F	4b	8- 8	9- 0	103	2.2	48	132
Pair 24	F	3a	8- 7	7- 4	85	3.4	..	...
	F	3a	8- 7	8- 2	95	3.3	..	...
Pair 25	M	1b	8- 2	7- 4	90	...	..	...
	F	1b	8- 2	8- 7	105	...	..	...
Pair 26	M	3b	8-11	10- 4	116	2.5	47	76
	F	3a	8-11	11- 6	129	2.3	48	150
Pair 27	F	..	8- 3	6- 8	81	...	..	...
	F	..	8- 3	6- 4	77	...	..	...
Pair 28	F	3a	8- 9	9- 0	102	2.9	..	...
	F	3a	8- 9	9- 0	102	2.8	..	...
Pair 29	F	4b	9- 0*	9- 5	104	3.5	45	114
	F	4b	8-11*	8-10	99	3.3	58	122
Pair 30	M	2a	8- 1	8- 4	103	3.0	37	48
	M	2a	8- 1	7-10	96	3.0	44	46
Pair 31	M	2a	8- 6	7- 9	91	3.5	32	102
	F	3b	8- 6	8- 0	94	3.3	46	118
Pair 32	M	2a	8- 6	7- 2	84	2.1	..	...
	F	2a	8- 6	7- 4	86	2.4	..	...
Pair 33	M	4b	8-11	....	...	2.1	43	...
	F	4b	8-11	....	...	2.4	47	...
Pair 34	M	3b	8- 5	....	...	3.8	..	...
	F	3a	8- 5	....	...	2.9	..	...
Pair 114	F	3a	8-11	....	...	...	..	57
	F	3b	8-11	....	...	...	..	67
Pair 115	F	3a	8- 2	....	...	...	..	84
	M	2a	8- 2	....	...	...	..	9
Pair 116	M	3b	8- 1	....	...	...	..	131
	F	3a	8- 1	....	...	...	..	142
Pair 117	F	3b	8- 4	....	...	...	..	106
	F	3b	8- 4	....	...	...	..	86
Pair 118	F	2a	8- 0	....	...	...	..	52
	F	3b	8- 0	....	...	...	..	83
Pair 119	F	3	8- 6	....	...	...	..	89
	M	3a	8- 6	....	...	...	..	68
Pair 120	F	3b	8- 6	....	...	...	..	56
	F	3	8- 6	....	...	...	..	107
Pair 121	F	4	8- 8	....	...	...	..	172
	M	4a	8- 8	....	...	...	..	101
Pair 122	F	3a	8-11	....	...	...	..	88

	SEX	GRADE	C.A.	M.A.	I.Q.	TEACHER	BETA	N.I.T.
	F	3a	8-11	....	...	...	..	104
Pair 35	F	4a	9- 6	10-11	115	2.9	53	214
	F	4b	9- 6	9- 3	97	3.8	41	198
Pair 36	F	5a	9-11	12- 2	123	2.6	61	268
	F	5a	9-11	11- 9	118	2.6	50	286
Pair 37	M	3b	9- 7	9- 0	93	3.2	41	114
	F	4a	9- 7	10- 3	106	3.0	60	218
Pair 38	M	2b	9- 0*	6- 7	73	4.5	34	...
	F	3b	9- 2*	8- 0	87	3.2	58	...
Pair 39	F	4a	9- 9	11- 0	113	2.2	66	240
	F	4a	9- 9	11- 1	114	2.1	66	258
Pair 40	M	5b	9- 9	10- 5	107	2.6	54	188
	M	5b	9- 9	10- 7	109	3.2	58	174
Pair 41	F	3b	9- 5	8- 9	92	3.3	47	138
	F	3a	9- 5	8- 4	89	3.4	45	142
Pair 42	M	3b	9- 5	8- 4	89	...	30	32
	F	4b	9- 5	9- 8	103	...	53	196
Pair 43	M	2a	9- 0	7- 6	83	3.6	22	108
	F	3b	9- 0	8- 2	91	3.7	37	106
Pair 44	F	3b	9- 8	9- 4	97	3.0	..	...
	F	2a	9- 8	9- 0	93	3.1	..	...
Pair 45	F	..	9- 4	7-10	84	...	..	...
	F	..	9- 4	8- 0	86	...	..	...
Pair 46	F	6b	9- 6	12-10	135	2.1	46	246
	F	6b	9- 6	12- 1	127	2.1	60	238
Pair 47	M	2b	9- 3*	8- 3	89	2.9	..	...
	M	1a	9- 2*	8- 2	89	3.3	..	...
Pair 48	M	5a	9-10	11- 7	118	3.0	41	148
	F	5a	9-10	11- 0	112	3.0	63	164
Pair 49	F	3a	9- 8	9- 4	96	...	..	...
	F	3a	9- 8	8- 4	86	...	..	...
Pair 123	F	3a	9- 7	....	...	...	..	47
	F	3a	9- 7	....	...	...	..	37
Pair 124	F	3a	9-11	....	...	...	..	33
	F	3a	9-11	....	...	...	..	33
Pair 125	F	3b	9- 5	....	...	...	..	82
	F	3b	9- 5	....	...	...	..	108
Pair 126	M	4b	9-11	....	...	...	..	135
	M	4a	9-11	....	...	...	..	111
Pair 128	M	4b	9- 9	....	...	...	..	87
	M	4b	9- 9	....	...	...	..	61
Pair 129	M	4b	9- 6	....	...	...	..	87
	M	4b	9- 6	....	...	...	..	86
Pair 130	M	4b	9- 3	....	...	...	..	152
	F	4b	9- 3	....	...	...	..	85
Pair 131	F	3a	9- 3	....	...	...	..	28
	F	2a	9- 3	....	...	...	..	2

	SEX	GRADE	C.A.	M.A.	I.Q.	TEACHER	BETA	N.I.T.
Pair 132	F	5a	9-10	....	...	...	..	159
	F	4b	9-10	....	...	...	..	144
Pair 133	F	4b	9-11	....	...	...	..	177
	M	4b	9-11	....	...	...	..	125
Pair 134	M	3b	9- 2	....	...	...	..	92
	M	3b	9- 2	....	...	...	..	80
Pair 50	M	5a	10- 6	12- 1	115	3.2	64	232
	M	5a	10- 6	12- 6	119	3.2	61	224
Pair 51	M	5a	10-10	11-10	109	2.1	75	202
	F	5b	10-10	10-11	101	3.5	77	220
Pair 52	M	4a	10- 1	9- 2	91	3.0	48	204
	F	4a	10- 1	8- 6	84	2.8	37	186
Pair 53	M	4a	10- 1	11- 6	114	2.6	64	232
	F	4a	10- 1	8- 5	83	3.4	46	156
Pair 54	M	4a	10- 6	9-11	93	3.2	64	160
	F	4a	10- 6	10- 4	99	2.2	63	184
Pair 55	F	4a	10- 1	10- 6	104	...	..	...
	F	3a	10- 1	11- 0	109	...	..	...
Pair 56	F	1a	10- 3	6- 7	65	...	..	...
	F	1a	10- 3	6- 3	61	...	..	...
Pair 57	M	..	10- 0*	14- 1	141	...	..	...
	M	..	10- 6*	13- 6	135	...	..	...
Pair 58	F	5a	10- 6	11-10	112	3.0	74	250
	F	5a	10- 6	11- 2	106	2.7	72	232
Pair 59	M	5a	10-10	.....	...	2.9	39	218
	F	5a	10-10	.....	...	2.6	54	262
Pair 60	M	5b	10- 6	.....	...	4.0	47	...
	F	5b	10- 6	.....	...	3.6	70	...
Pair 61	M	4b	10- 0	.....	...	2.0	..	...
	F	3a	10- 0	.....	...	4.0	..	...
Pair 135	F	5b	10- 8	.....	...	...	..	207
	F	5b	10- 8	.....	...	...	..	178
Pair 136	F	5b	10-10	.....	...	...	..	192
	M	5b	10-10	.....	...	...	..	169
Pair 137	F	4b	10-10	.....	...	...	..	133
	F	4b	10-10	.....	...	...	..	156
Pair 138	F	5b	10- 7	.....	...	...	..	171
	M	5a	10- 7	.....	...	...	..	148
Pair 139	F	4b	10-10	.....	...	...	..	147
	F	4a	10-10	.....	...	...	..	139
Pair 140	M	5a	10-11	.....	...	...	..	189
	F	4b	10-11	.....	...	...	..	197
Pair 142	M	3a	10-10	.....	...	...	..	72
	F	3a	10-10	.....	...	...	..	74
Pair 143	F	5a	10-10	.....	...	...	..	199
	F	5a	10-10	.....	...	...	..	189
Pair 144	F	3b	10- 6	.....	...	...	..	137

	SEX	GRADE	C.A.	M.A.	I.Q.	TEACHER	BETA	N.I.T.
	F	4a	10- 6	.....	...	...	..	136
Pair 62	M	4a	11-11	8- 6	71	4.1	44	116
	F	6b	11-11	9-10	83	3.0	60	204
Pair 63	M	6b	11-10	11- 2	94	2.9	68	214
	F	6b	11-10	11- 5	96	3.7	50	206
Pair 64	M	3b	11- 8	9-10	84	3.8	..	...
	M	3b	11- 8	7-11	68	3.8	..	...
Pair 65	M	3a	11- 5	9- 9	85	...	..	...
	M	3a	11- 5	9- 0	79	...	..	...
Pair 66	M	7b	11- 1	15- 5	139	...	..	...
	M	7b	11- 1	14-11	134	...	..	...
Pair 67	F	..	11- 7	8- 6	73	...	59	140
	F	..	11- 7	8- 6	73	...	49	146
Pair 68	F	7b	11-11	12- 5	104	2.7	74	294
	F	7b	11-11	13- 6	113	3.9	80	324
Pair 69	M	5a	11-11	11- 8	90	3.0	76	196
	F	6b	11-11	13- 0	111	1.7	80	292
Pair 70	M	6c	11- 1	11- 2	101	3.0	38	158
	M	6c	11- 1	11- 7	104	3.0	46	152
Pair 71	M	6a	11- 5	12- 4	108	2.4	73	258
	M	6a	11- 5	12-11	113	2.8	66	262
Pair 145	F	6a	11- 5	.....	...	...	..	196
	F	6a	11- 5	.....	...	...	..	185
Pair 146	M	7a	11- 2	.....	...	...	..	223
	F	7	11- 2	.....	...	...	..	255
Pair 147	F	5b	11- 1	.....	...	...	..	135
	M	5b	11- 1	.....	...	...	..	139
Pair 148	F	6a	11- 4	.....	...	...	..	274
	F	6a	11- 4	.....	...	...	..	294
Pair 149	F	6b	11- 7	.....	...	...	..	242
	M	4b	11- 7	.....	...	...	..	195
Pair 150	F	7	11- 5	.....	...	...	..	253
	F	7	11- 5	.....	...	...	..	257
Pair 151	F	6b	11- 5	.....	...	...	..	202
	M	7b	11- 5	.....	...	...	..	246
Pair 152	F	5a	11- 5	.....	...	...	..	131
	F	5b	11- 5	.....	...	...	..	183
Pair 153	F	5a	11-11	.....	...	...	..	169
	M	6b	11-11	.....	...	...	..	269
Pair 154	F	4a	11- 1	.....	...	...	..	141
	F	4a	11- 1	.....	...	...	..	124
Pair 72	F	6a	12- 7	11- 0	87	3.2	65	...
	F	6b	12- 7	10-10	86	3.2	62	...
Pair 73	M	5b	12- 1	11- 2	92	3.0	62	...
	M	5b	12- 1	10-11	91	3.0	59	...
Pair 74	M	6a	12- 0	11- 4	94	3.1	78	290
	F	6a	12- 0	12- 6	104	3.1	82	286

	SEX	GRADE	C.A.	M.A.	I.Q.	TEACHER	BETA	N.I.T.
Pair 75	F	7b	12- 9	12- 1	95	3.4	68	...
	F	7b	12- 9	12- 3	96	4.3	70	...
Pair 76	F	4a	12- 2	8- 2	67	3.5	54	126
	F	4a	12- 2	8-10	73	3.5	51	142
Pair 77	F	4a	12- 1	10- 4	85	2.6	51	...
	F	4a	12- 1	10- 4	85	2.3	63	...
Pair 78	M	7a	12-10*	14-10	116	2.9	62	...
	F	6b	12-11*	10- 7	82	3.3	88	...
Pair 79	M	6b	12- 5	10- 9	86	3.5	59	170
	F	6b	12- 5	10- 3	82	3.8	60	148
Pair 80	M	7b	12-10	9- 6	74	...	..	...
	M	7b	12-10	10- 1	79	...	..	...
Pair 81	M	..	12- 1	14- 8	121	...	..	...
	M	..	12- 1	15- 4	134	...	..	...
Pair 82	M	..	12- 0	12- 0	100	...	..	...
	F	..	12- 0	9- 0	75	...	..	...
Pair 83	M	..	12- 5	11- 5	90	...	..	...
	F	..	12- 5	11- 6	92	...	..	...
Pair 84	F	4a	12- 3	9- 2	75	3.1	41	94
	F	4b	12- 3	8-10	72	3.5	20	124
Pair 85	M	6a	12- 6	12- 6	100	1.9	83	254
	F	6a	12- 6	12-11	103	2.0	69	264
Pair 86	F	7b	12- 0	10- 6	88	3.8	77	264
	F	7b	12- 0	12-11	107	3.8	80	254
Pair 87	M	5a	12- 5	.....	...	3.1	56	...
	M	5a	12- 5	.....	...	3.1	43	...
Pair 155	M	6a	12- 5	.....	...	...	..	213
	M	6a	12- 5	.....	...	...	..	215
Pair 156	F	6b	12-10	.....	...	...	..	209
	F	6b	12-10	.....	...	...	..	247
Pair 157	M	4b	12- 6	.....	...	...	..	141
	M	5b	12- 6	.....	...	...	..	137
Pair 158	M	7b	12- 5	.....	...	...	..	266
	M	7b	12- 5	.....	...	...	..	233
Pair 159	F	5a	12- 4	.....	...	...	..	117
	F	6b	12- 4	.....	...	...	..	200
Pair 160	F	5b	12- 3	.....	...	...	..	178
	M	5b	12- 3	.....	...	...	..	125
Pair 161	F	7b	12- 3	.....	...	...	..	259
	F	7b	12- 3	.....	...	...	..	263
Pair 162	F	6a	12- 1	.....	...	...	..	169
	M	7b	12- 1	.....	...	...	..	203
Pair 163	F	6b	12- 7	.....	...	...	..	241
	F	6b	12- 7	.....	...	...	..	238
Pair 164	M	7a	12- 9	.....	...	...	..	263
	M	7b	12- 9	.....	...	...	..	241
Pair 165	M	2b	12- 0	.....	...	...	..	22

	SEX	GRADE	C.A.	M.A.	I.Q.	TEACHER	BETA	N.I.T.
	M	3b	12- 0	.....	...	...	..	51
Pair 166	M	5a	12- 2	.....	...	...	..	223
	M	5a	12- 2	.....	...	...	..	235
Pair 167	F	6a	12- 2	.....	...	...	..	221
	F	6a	12- 2	.....	...	...	..	201
Pair 168	F	7	12- 8	.....	...	...	..	248
	F	8b	12- 8	.....	...	...	..	277
Pair 169	F	7b	12- 3	.....	...	...	..	274
	F	7b	12- 3	.....	...	...	..	308
Pair 170	F	7a	12- 8	.....	...	...	..	281
	F	7a	12- 8	.....	...	...	..	305
Pair 171	F	5b	12- 4	.....	...	...	..	151
	F	5b	12- 4	.....	...	...	..	159
Pair 172	F	6a	12- 7	.....	...	...	..	240
	F	6a	12- 7	.....	...	...	..	235
Pair 173	M	8	12- 7	.....	...	...	..	285
	F	7	12- 7	.....	...	...	..	304
Pair 174	F	7a	12- 9	.....	...	...	..	219
	F	7a	12- 9	.....	...	...	..	225
Pair 88	F	8a	13- 4	14- 7	109	2.5	84	...
	F	8a	13- 4	16- 3	122	2.5	78	...
Pair 89	M	8a	13- 9	13- 6	98	2.6	60	300
	F	8b	13- 9	12- 0	87	3.4	73	300
Pair 90	F	7a	13- 2	12- 6	95	3.5	51	256
	F	7a	13- 2	9- 9	74	4.2	53	200
Pair 91	F	7a	13- 4	11- 9	88	3.2	77	224
	F	7a	13- 4	13- 5	101	2.3	89	264
Pair 92	M	8a	13- 8	13- 4	97	3.8	77	200
	M	8a	13- 8	13- 9	100	2.9	62	226
Pair 93	M	8b	13- 8	16- 0	117	2.2	82	296
	M	7a	13- 8	12- 8	93	2.6	85	280
Pair 94	F	8a	13-10	14- 5	104	...	80	296
	F	8a	13-10	14- 3	103	...	78	296
Pair 95	M	7a	13- 6	13- 2	98	3.0	74	298
	M	7a	13- 6	13- 3	98	2.9	69	320
Pair 96	M	8a	14- 4*	13-10	97	2.7	78	330
	F	7b	14- 3*	13- 1	92	3.0	59	258
Pair 97	M	5a	13- 4	.....	...	3.6	57	...
	M	5a	13- 4	.....	...	3.9	44	...
Pair 98	F	5b	13- 2	10- 7	80	3.5	66	180
	F	5b	13- 2	10- 8	81	3.2	54	202
Pair 176	F	6a	13- 2	.....	...	...	..	202
	F	6a	13- 2	.....	...	...	..	240
Pair 177	M	8a	13- 9	.....	...	...	..	337
	F	7b	13- 9	.....	...	...	..	222
Pair 178	M	8a	13- 4	.....	...	...	..	266
	M	8b	13- 4	.....	...	...	..	190

	SEX	GRADE	C.A.	M.A.	I.Q.	TEACHER	BETA	N.I.T.
Pair 179	M	8a	13-11	.....	...	...	..	273
	M	8a	13-11	.....	...	...	..	270
Pair 180	F	8a	13- 5	.....	...	...	..	304
	F	8b	13- 5	.....	...	...	..	246
Pair 181	M	7a	13- 3	.....	...	...	..	269
	M	7a	13- 3	.....	...	...	..	157
Pair 182	M	9b	13- 4	.....	...	...	..	295
	M	9b	13- 4	.....	...	...	..	299
Pair 183	F	8a	13-10	.....	...	...	..	219
	F	8a	13-10	.....	...	...	..	252
Pair 184	M	7a	13- 2	.....	...	...	..	264
	F	8b	13- 2	.....	...	...	..	308
Pair 185	M	6a	13- 7	.....	...	...	..	216
	M	7a	13- 7	.....	...	...	..	231
Pair 186	F	7b	13- 0	.....	...	...	..	232
	F	7b	13- 0	.....	...	...	..	224
Pair 187	M	7b	13- 2	.....	...	...	..	304
	F	7b	13- 2	.....	...	...	..	290
Pair 99	M	6a	14- 0	13-10	99	3.4	84	318
	M	6a	14- 0	12- 7	90	3.4	98	244
Pair 100	M	7a	14- 9	11- 9	80	4.2	67	...
	M	8b	14- 9	12- 7	85	4.0	81	...
Pair 101	M	8a	14- 7	15- 2	104	3.3	83	...
	F	8b	14- 7	13- 7	93	4.0	91	...
Pair 102	F	8b	14-10	12- 9	86	2.4	..	276
	F	8b	14-10	11- 5	77	4.4	..	264
Pair 103	F	7a	14- 7	9- 3	63	4.4	62	126
	F	8b	14- 7	12- 7	86	4.3	71	194
Pair 104	M	7b	14- 8	12- 3	83	3.5	69	188
	M	7b	14- 8	12- 2	83	3.4	73	208
Pair 105	M	8a	14-10	13-11	94	3.3	91	262
	F	8a	14-10	13- 4	90	2.8	90	286
Pair 106	M	5a	14- 6	11- 8	80	4.2	62	170
	F	5a	14- 6	10- 8	74	3.5	63	186
Pair 107	F	8a	14- 3	14- 5	101	1.8	82	...
	F	8a	14- 3	15- 2	107	1.5	85	...
Pair 188	M	7b	14- 6	.....	...	...	..	201
	F	7b	14- 6	.....	...	...	..	227
Pair 189	F	8a	14- 0	.....	...	...	..	292
	F	8a	14- 0	.....	...	...	..	252
Pair 190	M	7b	14- 5	.....	...	...	..	183
	M	7a	14- 5	.....	...	...	..	207
Pair 191	M	7a	14- 9	.....	...	...	..	181
	M	7b	14- 9	.....	...	...	..	162
Pair 192	M	8a	14- 6	.....	...	...	..	198
	F	9a	14- 6	.....	...	...	..	243
Pair 193	F	8a	14- 2	.....	...	...	..	253

	SEX	GRADE	C.A.	M.A.	I.Q.	TEACHER	BETA	N.I.T.
	F	7b	14- 2	.....	...	...	..	217
Pair 194	M	7b	14- 2	.....	...	...	..	188
	F	7b	14- 2	.....	...	...	..	209
Pair 195	F	8a	15- 4	.....	...	...	..	227
	F	8a	15- 4	.....	...	...	..	217
Pair 196	F	8a	15- 0	.....	...	...	..	260
	M	9b	15- 0	.....	...	...	..	298
Pair 197	M	9b	15- 1	.....	...	...	..	248
	F	8b	15- 1	.....	...	...	..	200
Pair 198	M	7b	15- 6	.....	...	...	..	235
	F	7a	15- 6	.....	...	...	..	232
Pair 199	F	8a	15- 2	.....	...	...	..	239
	F	9b	15- 2	.....	...	...	..	263
Pair 200	M	8a	15- 1	.....	...	...	..	261
	M	8b	15- 1	.....	...	...	..	267
Pair 201	M	8	15- 7	.....	...	...	..	232
	M	8	15- 7	.....	...	...	..	212
Pair 202	F	8a	15-10	.....	...	...	..	192
	F	8a	15-10	.....	...	...	..	218
Pair 108	F	8b	15- 2	12- 8	84	3.7	..	...
	F	8b	15- 2	11-10	78	2.8	..	...
Pair 109	M	6a	15- 0	13- 0	87	3.5	70	214
	M	8b	15- 0	14- 8	98	2.7	79	274
Pair 110	M	7b	15- 9	14- 1	94	2.8	80	198
	F	6b	15- 9	12- 5	79	3.7	68	174
Pair 111	F	..	16- 5	16- 8	102	...	..	...
	F	..	16- 5	16- 8	102	...	..	...
Pair 112	M	8b	16-11	11- 3	67	3.5	..	...
	F	9a	16-11	11-11	70	3.5	..	...
Pair 203	M	8b	16- 5	.....	...	...	..	178
	M	8b	16- 5	.....	...	...	..	190
Pair 204	F	7a	18- 2	.....	...	...	..	104
	F	9a	18- 2	.....	...	...	..	75